A meta-analysis study of project and programme management complexity in the oil and gas sector of the Middle East and North Africa region

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Table of Acronyms

ALPN	Agile Project Leadership Network
APM	Association for Project Management
CAS	Complex Adaptive System
CIFTER	Crawford-Ishikura Factor Table for Evaluating Roles
CLIOS	Complex, large-scale, integrated, open systems
CRPR	Complex Responsive Processes of Relating
CT	Complexity theory
EMS	IEEE Engineering Management Society
ES	Effect Size
GAPPS	Global Alliance for Project Performance Standards
ICCEPM	International Conference on Construction Engineering and Project Management
ICD	Integration Centric Development
IPMA	International Project Management Association
ISDP	Information Systems Development Projects
KPI	Key Performance Indicator
MENA	Middle East and North Africa

MIT	Massachusetts Institute of Technology
MODeST	Mission, Organization, Delivery, Stakeholders and Team
NCTP	Novelty, complexity, Technology, and Pace
O&G	Oil and Gas
PfM	Portfolios Management
PM	Project Management
PMBOK ®	Project Management Body of Knowledge
PMI	Project Management Institute
PMINZ	National Project Management Conference in New Zealand
PPPM	Projects, Programs, and Portfolios Management
PMOz	Project Management Australia Conference
PMS	Performance Measurement System
QA/QC	Quality Assurance / Quality Control
QAI	Quality Assurance Global Institute
SD	System Dynamics
SQE	Software Quality Engineering
SWOT	Strengths, Weaknesses, Opportunities and Threats
TQM	Total Quality Management

UCP	Uncertainty, Complexity, and Pace
UoM	University of Manchester

List of Publications, Conferences, and Events

Technical Papers:

1. **On the Edge of Chaos: Complexity Offering Value Expectations on O&G Projects**

    Ziadat, WaEL, Weatherford. Kirkham, Richard, University of Manchester.

    Gardiner, Paul, SKEMA Business School.

    SPE Paper 188129-MS– 2017.

2. **The Way Forward in Oil & Gas Projects: Understanding Complexity through Meta-analysis**

    Wael Ziadat, The University of Manchester

    Journal of Modern Sciences, ISSN: 2349-3755, 2016.

3. **On the Edge of Chaos, Engineering Complex Projects.**

    Wael Ziadat, Richard Kirkham, The University of Manchester

    The 2nd Kuwait Project Management Conference, 2018.

4. **First Application of Extended Range Electromagnetic MWD Technology - Case Study and Lesson Learned**

   Saleem, Saad, Sattar, Suhail, PPL limited Shahzad, Atif, Ziadat, Wael, Weatherford Oil Tools M.E. Limited.

   163126-MS SPE Paper - 2012

Conference Proceedings

1. **ADNOC subsurface and Drilling Conference and Exhibition, 2013.**

   'On the edge of chaos': Does complexity theory offer solutions to improve clients' value expectations of coping with uncertainty in oil and gas projects?

2. **SPE Asset Integrity Management–Changing the Culture, Raising the Bar conference, 2014**

   Co-Chair Risk Management Session and presented on Complexity in Projects.

Workshops & Events

1. **The Abu Dhabi International Petroleum Exhibition and Conference (ADIPEC), 2012, 2014.**
2. **BUiD Annual Doctoral Research Conference, 2015.**
3. **SPE-KSA Annual Technical Symposium & Exhibition (ATS&E), 2017.**

Abstract

Projects and programmes are inherently complex; the interaction of people, systems, processes and data within a dynamic environment creates an intricate network of agents whose behaviour can be unpredictable and unexpected. The management of this complexity is ordinarily concerned with the implementation of tools and techniques to ensure that projects are completed within the desired cost and time, at the agreed level of performance and quality – this is often referred to as the 'iron triangle'. However, the impact of a dynamic external environment on the 'soft' boundaries of the project domain can lead to extreme difficulty in attempting to forecast or predict outcomes and system behaviours. This thesis contends that there is a clear desideratum for a new paradigm in project management practice and research that moves beyond the traditionalist (reductionist) approach to one that embraces, rather than attempts to simplify complexity.

The research described in this thesis seeks to uncover the characteristics of complexity, in the context of projects and programmes, in an attempt to uncover if complexity is a factor in the determination of 'valuable' outcomes. Subsequently, and through the theoretical lens of complexity theory, this research seeks to highlight the importance of our understanding and treatment of complexity in the execution and management of projects and programmes. The research further seeks to demonstrate how complexity thinking may inform a more sophisticated understanding of how projects, programmes and portfolios delivered successfully (Ziadat, 2017).

The context of the research is the oil and gas (O & G) engineering sector in the Middle East and North Africa (MENA) region. A two stage qualitative and quantitative methodology is applied, based on deductive reasoning. The first stage involves the development of a questionnaire and a series of unstructured interviews to gain an understanding of the practical consideration that emerges from the literature review. The second stage of the research involves the application of meta-analysis to study the correlation between the complexity factors identified in the first stage, aiming for heterogeneity, identification of patterns and directing to achieve robust conclusions by using sensitivity analysis. The thesis proposes a new model of complexity factors for oil & gas engineering projects in the MENA region. The model is designed to facilitate the analysis of the project complexity landscape and to define requirements for oil & gas organisations involved with the delivery of projects and programmes to cope with different complexity factors within and across the MENA region. The outcomes include substantial relationship between technical and health, safety & environment complexity factors and project performance despite the mediation of project management complexity factors, yet the organizational complexity factors can be observed at a significant level when project management in complexity factors are considered as a mediator in the model (Ziadat, 2016).

Declaration

No portion of the work referred to in the thesis has been submitted in support of an application for another degree or qualification of this or any other university or other institute of learning.

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1. Introduction

Projects and programmes are inherently complex; the interaction of people, systems, processes and data within a dynamic environment creates an intricate network of agents whose behaviour can be unpredictable and unexpected. The management of this complexity through project management is ordinarily concerned with the implementation of tools and techniques to ensure that projects are completed within the desired cost and time, at the agreed level of performance and quality – this is often referred to as the 'iron triangle'. However, the impact of a dynamic external environment on the 'soft' boundaries of the project domain can lead to extreme difficulty in attempting to forecast or predict outcomes and system behaviours (Kerzner, 2013). This thesis contends that there is a clear desideratum for a new paradigm in project management practice and research that moves beyond the traditionalist (reductionist) approach to one that embraces, rather than attempts to simplify complexity.

The characteristics of complexity, in the context of projects and programmes, is explored and challenged in an attempt to uncover why complexity may be one of the primary reasons why projects often fail to deliver 'valuable' outcomes. Subsequently, and through the theoretical lens of complexity theory, this research seeks to highlight the importance of our understanding and treatment of complexity in the execution and management of projects and programmes. Emergence, and emergent behaviour, is one of the fundamental characteristics of a complex system; complexity is also often described as the 'edge of chaos', the region between order and chaos where innovation is created – the region in a system where emergent behaviour creates opportunities and threats. The research further seeks to demonstrate how complexity thinking may inform a more sophisticated understanding of how projects, programmes and portfolios deliver successful outcomes (Cooke-Davies et al., 2011).

1.1. Background to the research

The project management literature is characterised by many examples of ex-post critical evaluations of projects that are observed as 'failures' (see Kirkham, 2015) – in fact, one can argue that this discourse has become a preoccupation in the project management community for some time now. While the focus remains inclined towards budget (more specifically, budgets which, have been exceeded) the literature tends to afford relatively little analysis of the underlying complexity underpinning these 'failures'. Whilst the project management discipline is characterized by largely reductionist approaches, academics and practitioners are now increasingly interested in adopting a holistic view of projects, which arguably requires a fundamentally different theoretical lens to the classical reductionist methodologies.

Drawing on data gathered as part of the Standish Chaos Report (2015), this research observes a project success rate of circa 29%; this approximates well to the 33% success rate of projects observed in the KPMG Project Management Survey Report of 2013 (KPMG, 2013). The report emphasises the criticality of project, programme and portfolio management in the delivery of organisational strategy (and policy in the context of government) and the continuous search for methodologies and techniques, which are sympathetic to this higher level 'outcome' based view. In this research, it is argued that in order to maintain or increase the financial sustainability and agility of an organisation; its goal and objectives must be aligned with the portfolio of programmes and projects that it commissions. The dilemma of reliance on traditional project management methodologies and the ever-present evidence of project failures has led academics and practitioners to question the validity of reductionism (Cicmil and Hodgson, 2006). Table 1-1 observes a significant reduction in the success rates of projects captured in the KMPG survey by time, budget and scope (deliverables) in the period 2010-2015.

Table 1-1 [Projects Success and Failure percentages (Project Management Survey Report by KPMG, 2015)]

	2010	2012	2015
Consistently on budget	48%	33%	31%
Consistently on time	36%	29%	17%
Consistently on deliverables	59%	35%	47%

If we are comfortable with the notion that complexity is one of the principal features of projects and programmes, by extension, project and programme management involves the planning and control of complexity. In this thesis, it is postulated that understanding complexity through an appropriate theoretical lens may help us to figure out why some projects or programmes fail to achieve the desired outcomes despite best endeavours and good management of the resources available. A greater understanding of complexity and its impact on the project system may enable us to identify the deficiencies of 'standard' contemporary tools, methods and techniques. A greater understanding of complexity in projects and programmes may further assist us in anticipating the consequences of complexity on project and programme performance (Ziadat, 2017).

The basis of our current understanding of complexity theory is entrenched in the natural sciences (see Kauffman 1995, 2000; Holland 1995, 1998), organisational studies (see Richardson, 2005, 2008; Stacey, 2000, 2001), health and social care (see Goldberger, Rigney and West, 1990; Durie and Wyatt, 2007), management sciences (see Allen, 2001; McElroy, 2000; Johnson and Burton, 2007) and economics (Baumol and Benhabib, 1989; Kelsey, 1988). In the project management space, there has been a marked increase in complexity related literature (see Williams, 2017, 2002, PMI 2014)

Ultimately, complexity theory attempts to model the processes of project management and challenges the traditional success factors used in projects and programme evaluation; it is also postulated that it encourages a rethink of risk and uncertainty too. Complexity theory further introduces the human dimension by attempting to cast a light on our understanding of socio-technological and socio-economic aspects (Sussman, 2010) and the different dimensions related to positive and negative feedback processes in projects (Sterman, 2000; Stacey, 2011). These factors will act as a differentiating feature for project team selection and it will further lead to an impact on project managers and decision maker's evaluation, training and competency (Cooke-Davies et al., 2011). Complexity theory also tends to challenge the assumption that project management should strive for equilibrium, since it focuses on long term planning in a different way by tolerating proper reactions to emergence (Pasian et al., 2012).

1.2. Research Aim and Objectives

This research aims to understand how project and programme managers cope with the effects of complexity. The thesis develops a contemporary understanding of how the characteristics of complexity build up and extend across portfolio of projects and programmes. The objectives are of the study are, therefore:

i. To critically review the extant literature and attempt to characterise the landscape of project and programme complexity research, drawing on academic, professional practice and professional bodies of knowledge,

ii. To identify the effects and consequences of complexity on project and programme processes throughout the life cycle and generate an understanding of how complexity may ultimately influence project and programme performance,

iii. To identify techniques for coping with complexity in projects and programmes whilst being mindful of scope outputs and outcomes

iv. To establish appropriate methods suitable for projects and programme management that enable project stakeholders to maximise the benefits,

v. To develop a model to identify project, programme and portfolio's complexity during the entire overview of research methodology.

vi. To identify the limitations of the proposed model and identify recommendations for further research in the field.

In order to address the aims and objectives of this study, the research draws on an international body of literature and then focuses on the oil and gas (O & G) engineering sector in the Middle East and North Africa (MENA) region for the purposes of data collection and analysis. This is explained in more detail in chapters 3, 4 and 5.

In order to investigate complexity in the project and programme management space, a purely quantitative or purely qualitative approach is unlikely to achieve a satisfactory outcome to the achievement of the aims and objectives. It is perhaps pertinent to observe however, that the majority of research in the field tends to adopt a qualitative approach. Wallace's 1971 'wheel of science' describes the concept of deductive and inductive reasoning. The deductive approach starts with a theoretical base and leads to hypotheses testing, which may prove or disprove new theories. The inductive approach starts by observing different patterns confirmed by testing a hypothesis, which further leads to the development of a new theory.

1.3. Statement of the research problem

In order to fulfil the research objective the following problem statements have to be accomplished:

a. What are the benefits and limitations of quantifying project complexity from a practitioner's point of view?
b. How can project complexity be categorised into complex engineering projects?
c. What factors and measures contribute towards Project, Programme, and Portfolio complexity and how do they influence a project's outcome and performance.
d. What are the procedures and controls of managing project complexity?
e. How can complexity theory be utilised to improve the performance of complex projects?
f. How can the concepts of complexity and emergence reproduce the project management framework?

1.4. Research Hypothesis

This thesis describes a research approach that is characterised by two fragments of hypothesis testing to support the research strategy used. The first fragment relates to the survey data, and then second to apply meta-analysis, the researcher develops two fragments of hypothesis to match research strategy used. Considering the first research strategy, part one hypothesis used as per the model illustrated in figure (1-2).

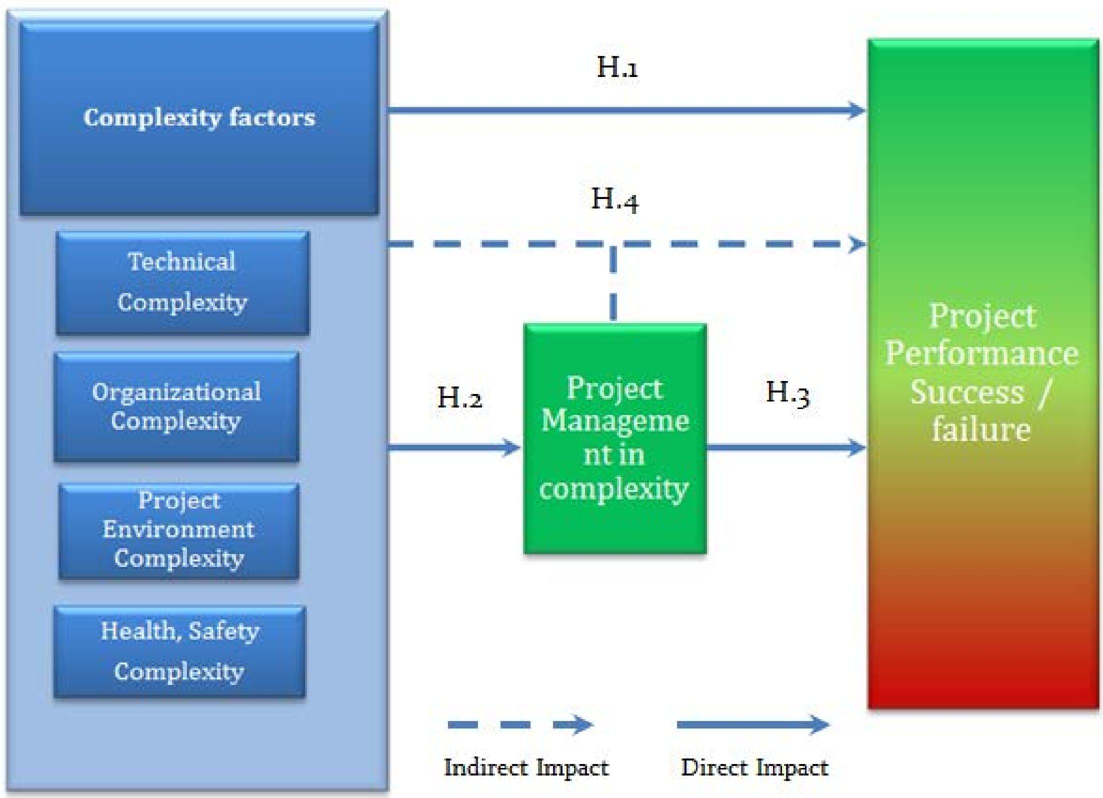


Figure 1-2 [Projects Complexity and Performance Model]

Initially, researcher discusses the direct relation of Complexity factors and Project Performance in H.1. Where H.1 definite in a four sub-hypotheses below:

H.1.1: There is relation between Technical Complexity and Project Performance at ($\alpha \leq$0.05).

H.1.2: There is relation between Organisational Complexity and Project Performance at ($\alpha \leq$0.05).

H.1.3: There is relation between "Project Environment Complexity ", and "Project Performance at ($\alpha \leq$0.05).

H.1.4: There is relation between "Health, Safety & Environment Complexity ", and "Project Performance at ($\alpha \leq$0.05).

Furthermore, researcher debates the direct relation of Complexity factors and Project Management in complexity in H.2.

H.2.1: There is relation between "Technical Complexity ", and "Project Management in complexity *at ($\alpha \leq$0.05).*

H.2.2: There is relation between "Organisational Complexity", and Project Management in complexity *at ($\alpha \leq$0.05).*

H.2.3: There is relation between "Project Environment Complexity ", and Project Management in complexity *at ($\alpha \leq$0.05).*

H.2.4: There is relation between "Health, Safety and environment Complexity ", and Project Management in complexity *at ($\alpha \leq$0.05).*

Moreover, researcher discusses the direct relation between Project Management in complexity and Project Performance in H.3 will be tested.

H.3: There is relation between Project Management in complexity and Project Performance at ($\alpha \leq 0.05$).

Finally: H.4 is tested based on four sub-hypotheses.

H4.1: Project Management in complexity mediates the relation between "Technical Complexity" and "Project Performance at ($\alpha \leq 0.05$).

H.4.2: Project Management in complexity mediates the relation between "Organisational Complexity" and "Project Performance at ($\alpha \leq 0.05$).

H4.3: Project Management in complexity mediates the relation between "Project Environment Complexity" and "Project Performance at ($\alpha \leq 0.05$).

H.4.4: Project Management in complexity mediates the relation between "Health, Safety and environment Complexity" and "Project Performance at ($\alpha \leq 0.05$).

In the second phase of the research, meta-analysis will be used to study the correlation between the complexity factors under focus in order to understand the common complexity factors within research under investigation. The researcher proposed the following five assumptions groups to further investigate these issues:

Group A: Technical category

1) **A1**: Non-alignment of project goals has a significant impact on increasing project complexity.
2) **A2:** Clarity of goals has a significant impact on increasing project complexity.
3) **A3**: Project Team competency "Technical perspective" has a significant impact on increasing project complexity.
4) **A4:** Technical complexity has a significant impact on increasing project complexity.

Group B: Organisational category

1) **B1**: Financial risks have a significant impact on increasing project complexity.
2) **B2**: Project leadership has a significant impact on increasing project complexity.
3) **B3:** Projects management complexity has a significant impact on increasing project complexity.

Group C: Project Environment category

1) **C1**: Safety of environment (Region, country, or city) has a significant impact on increasing project complexity.

2) **C2**: Political Stability of environment (Region, country, or city) has a significant impact on increasing project complexity.

3) **C3**: Instability of Oil Prices has a significant impact on increasing project complexity.

Group D: Health, Safety, & Environment (HSE)

1) **D1**: Operational risks' affecting processes and people has a significant impact on increasing project complexity.

2) **D2**: Corporate environmental responsibilities have a significant impact on increasing project complexity.

3) **D3**: Project location safety and security concerns have a significant impact on increasing project complexity.

Group E: Project Management in Complexity

1) **E1**: Dependencies between tasks has a significant impact on increasing project complexity.

2) **E2**: Interdependency between used Technologies has a significant impact on increasing project complexity.

3) **E3**: Compatibility of different pm methods and tools has a significant impact on increasing project complexity.

4) **E4**: Interfaces between different disciplines have a significant impact on increasing project complexity.

5) **E5**: Number of different cultures has a significant impact on increasing project complexity.

6) **E6**: Interdependence with other projects within organisation has a significant impact on increasing project complexity.

7) **E7**: Communication within project teams and stakeholders has a significant impact on increasing project complexity.

8) **E8**: Project Environment change has a significant impact on increasing project complexity.

9) **E9**: Interaction with governments and regulatory bodies has a significant impact on increasing project complexity.

10) **E10**: Media influence has a significant impact on increasing project complexity.

1.5. Research Methodology

A mix of qualitative and quantitative methods is used in this research, characterised by two distinct but sequential phases. The first phase involves the development of a questionnaire and structured interviews with research participants identified in the study. This phases draws upon qualitative research methodology. The second phase utilises a specific quantitative method, meta-analysis, which is defined by Neill (2006) as 'a statistical technique for amalgamating, summarising, and reviewing previous quantitative research'. Meta-analysis enables the researcher to ask a wide variety of questions provided that a substantial body of primary research exists in the domain. It intends to cover all the studies that are related and independent of this phase, and to identify patterns by using sensitivity analysis. Moreover, it also facilitates the outcomes of this research by lending greater weight to higher quality research undertaken in the field of project and programme complexity (Cooper et al., 2009).

In this research, a deductive approach is utilised to enhance learning and participation, and detailed information is obtained from participants in the form of case studies. In the first phase, questionnaires are developed in accordance with the research objectives and distributed amongst the chosen sample. The sample selected for research consists of engineering societies working in project and programme management environments and the data collection is based on snowball sampling techniques. In the next phase, this research conducts interviews with participants involved in projects and programmes in the oil and gas sector, where evidence of complexity exists, and a clear view of various factors that contribute towards project complexity and how this could affect project performance.

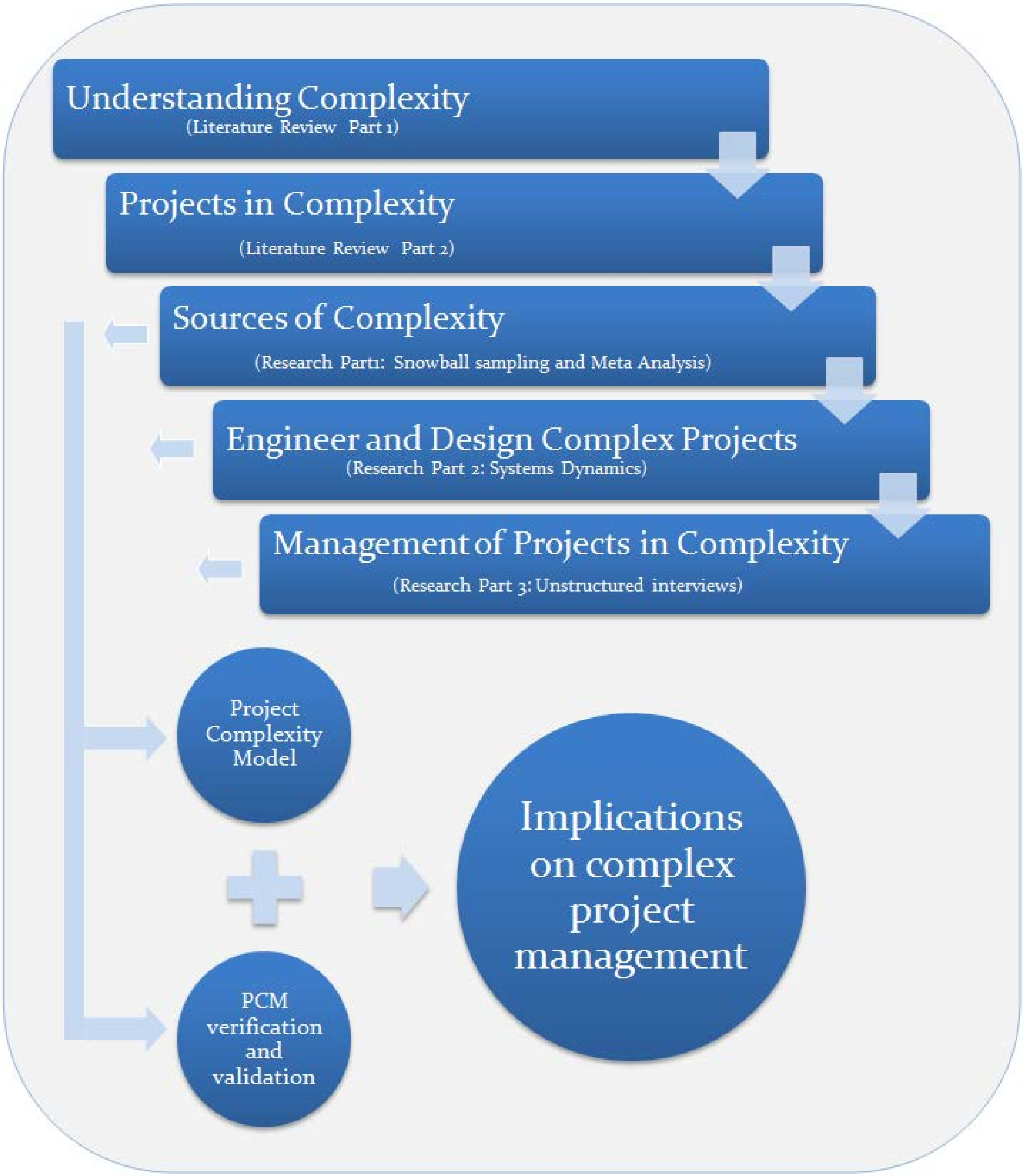


Figure 1-3 [Research Design and Model]

Based on the meta-analysis assumptions, those have been used in this research to develop a conceptual model mentioned in section 1.4. The proposed conceptual model makes a novel contribution since (a) it includes a number of consistent influential factors for the project's complexity; (b) it can be used as a frame of reference for the comparison in different categories. The model proposes five dimensions namely.

After the development of the conceptual model, the selection and justification of an appropriate research methodology are taking place. For the purpose of this research as explained in Section 3.2, a meta-analysis was selected to contact this part of the research. This leads to the next stage, which is to identify the moderator variables, and formation pre-understanding and initial theoretical offering as illustrated in Figure 1.3. Thereafter, the establishing criteria for including and excluding are conducted to develop a research protocol. Based on the need to collect the data, it was decided that the research design would utilise a vote counting and "d" effect size strategy through the employment of meta-analysis research methods. These are explained in more details in the following sections in chapter 3.4.

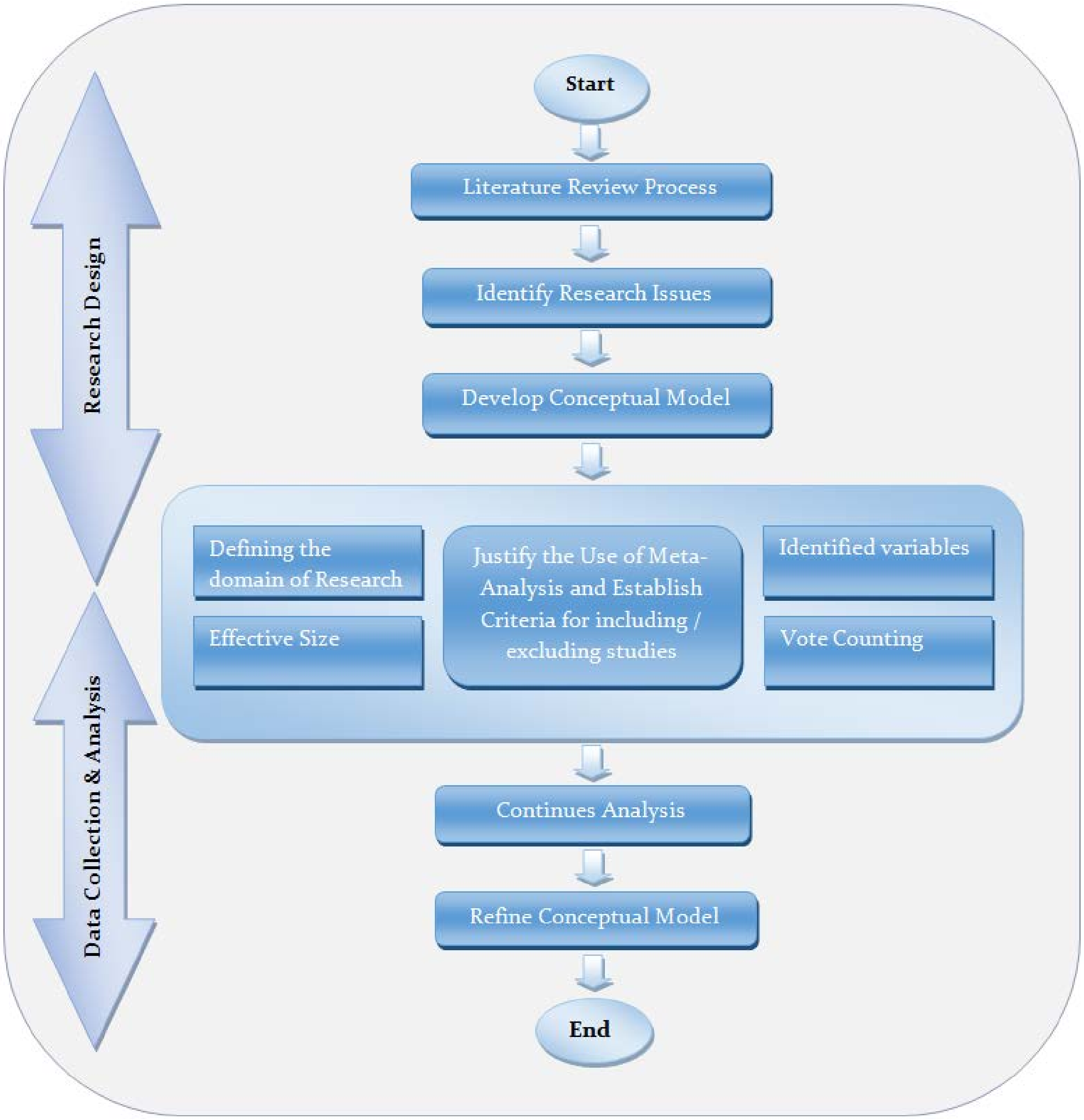


Figure 1-4 [Empirical Research Methodology for Meta-analysis]

1.6. Research Limitations

There are a number of limitations to this study. The first limitation emerged during the literature review stage; the volume of available literature on the research topics and sub themes challenged the researcher to produce as concise an account of the state-of-the art as is possible. In the particular field of oil and gas projects and programme management, the literature is narrower and this is certainly the case in the application of meta-analysis techniques, and therefore, the literature is limited in this domain.

The second limitation appeared during the sampling phase of the questionnaire survey, where it was found difficult to implement the snowball sampling technique due to plenty of questions in the survey and the difficulty of understanding the motif in O&G projects population. This in return has the potential for generalisation or stopping the survey process; however, the complexity science understating and approach was adopted with the aim to provide efficient data to relate to project manager's experiences and preferences within oil and gas community.

1.7. Justification for the research

Complexity theory is a set of certain concepts and principles emerged through the theoretical framework, which assists in handling complex systems. In recent years, increasing attention has been given to facilitate academics and practitioners define critical success factors and limitations in order to enable them to develop certain policies and strategies that would aid the success of projects. However, the entire work in this regard has only scratched the surface and barely produced a structured discipline for project management settings in the real world (Cooke-Davies et al., 2011).

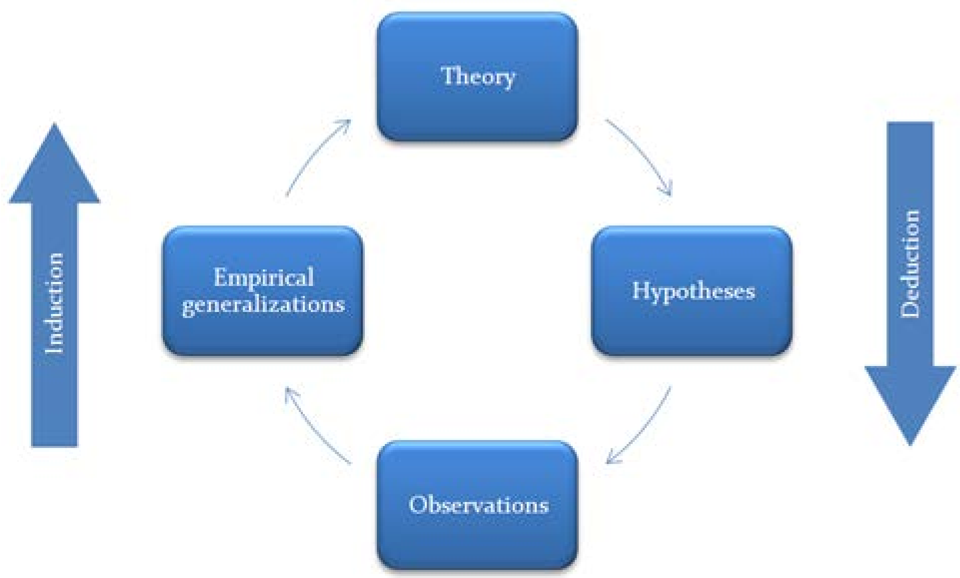


Figure 1-5 [Wheel of Science (Wallace, 1971)]

Generally, deductive reasoning is associated with the hard paradigm of project management and inductive reasoning with the soft paradigm of project management (Pollack, 2007). Therefore, in this research, the deductive approach is utilised to enhance learning and participation and detailed information will be obtained from participants in the form of case studies. In the first phase, questionnaires are developed according to our research objective and distributed among the chosen sample. The sample selected for research consists of engineering societies working in project management environment and data collection will be based on snowball sampling.

In the next phase, researcher will conduct an interview of people with a solid understanding of executing projects in complexity and a clear view of various factors that contribute towards project complexity and how this could affect project performance and reflected on engineering complex projects (Ziadat, 2016).

Furthermore, Meta-analysis, a statistical technique combines and contrasts the findings of independent studies in the project complexity field. It intends to cover all the related and independent studies, look for the presence of heterogeneity, identify patterns and aims to achieve robust conclusions by using sensitivity analysis. Quality effects models can facilitate the outcome by giving weight to higher quality research completed in the Projects complexity (Cooper et al., 2009).

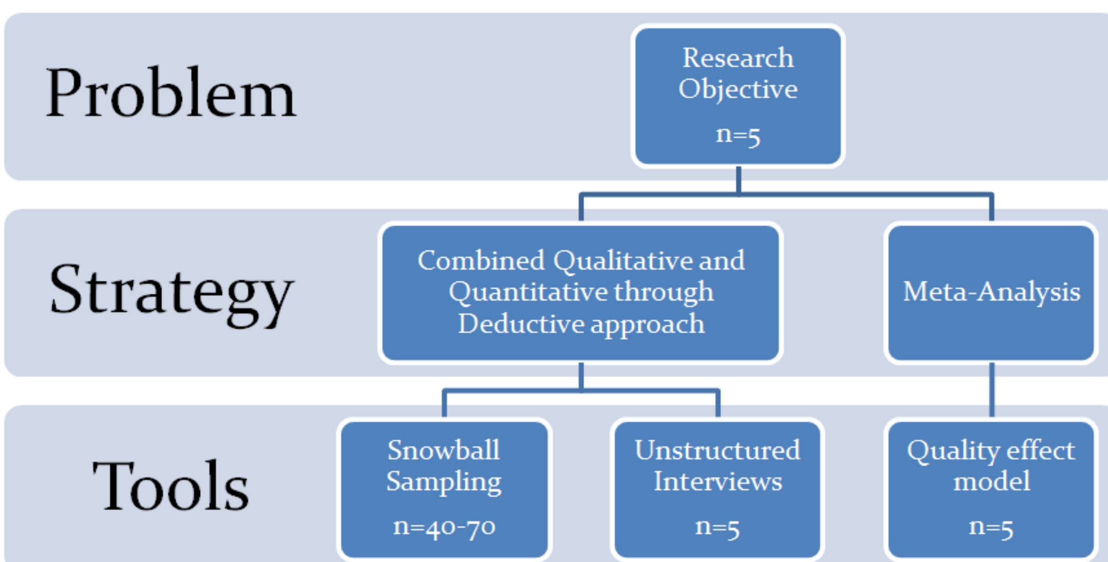


Figure 1-6 [Research Methodology Guide]

1.8. Summary

In This research seeks to explore the complexity of oil and gas project and programme management in the Middle East North Africa (MENA) region through the theoretical lens of complexity. The research methodology adopted is based on the deductive approach, which starts with a theoretical base leading to a set of hypotheses. It is not the intention of the researcher to develop a new theory (or theoretical contribution) – which leads to the rejection of the inductive approach.

Furthermore, the research demonstrates that application of meta-analysis, a statistical technique that combines and contrasts the findings of independent research studies - in the case of this research, across the body of research in the field of project and programme complexity. The research intends to cover all the related and independent studies identified, examine for the presence of heterogeneity, and identify patterns and ultimately aims to achieve robust conclusions through the application sensitivity analysis. Quality effects models can further facilitate the reliability of the outcome by lending weight to higher quality research published in the field.

The theoretical lens taken in this research is complexity theory, it integrates the complex behaviour as it emerges from simple rules, yet it’s focused on the network structure of complex systems and interdependency of those systems that evolve the simple rules outcome to form an emergent behaviour for the whole system(s). This ability to build adaptive capacity is what gives complexity in the system and the projects attractive aspect; since it will be inherited within the strategic level and form systems dynamics that maximise benefits for organisations and support team complex collaboration. This paradigm shift guides this research and provides a focus to explore the very essence of complexity within oil & gas projects, programmes and organisations.

2. Literature Review

2.1. Introduction

An organisation whether it is profit seeking or societal, operate in complex environment. The recent events that characterize the global economic recession illustrate this vividly. This dynamic complexity presents numerous challenges to organisations seeking to accomplish their corporate strategy. Most organisations strive to deliver their strategy through Project, Programme and Portfolio's (P3M) Therefore; it is important to understand the processes, tools and techniques that are used to achieve this. This chapter will seek to reveal the contemporary literature on P3M with a focus on the implications of modern day thinking in complexity.

British Standard Institution defines a project as "*unique process, consisting of a set of coordinated and controlled activities with start and finish dates, undertaken to achieve an objective conforming to specific requirements, including the constraints of time, cost and resources.*" The situation becomes more 'interesting' when an organisation is operating multiple projects (programme s or portfolio's) to ensure that its limited resources are aligned appropriately to meet the time, cost and performance requirements. However, failure to achieve this can lead to poor quality of outcomes along with serious delays in project deliveries, budget constraints and higher failure rates (Levine, 2005).

Modern Programme Management is surrounded by inputs, processes and outputs and not by outcomes. Outputs are based on certain practices with control over the inputs and process while the outcomes are based on the entire environment. Control inputs and processes deliver targeted outputs; while outputs, on the other hand, are fictitious most of the time and do not necessarily perceive the organisation's objectives (Gardiner, 2005; Pritchard, 2004; Kerzner, 2009). Applying different management style using project management methodologies to deliver a general programme may not succeed. This is because programme management demands adapting the changes that are required to attain the desired outcome of the projects within the programme and its environment. Whereas, project management focuses on minimizing the required changes in order to deliver the outcomes efficiently. This is achieved by targeting efficiency of projects and effectiveness of programme s (Patanakul and Milosevic, 2008).

The portfolio is a group of projects and (or) programme s set together to aid efficient management of resources to incorporate organisation objectives. These projects and programme s may not essentially be dependent or related. Portfolio management is referred to management for several projects and programme s by categorizing, prioritizing and approving projects and programme s to accomplish targeted strategic organisation objectives. In addition, it is also about controlling projects and programme s to guarantee delivery of targeted strategic outcomes in terms of quality, cost, schedule and scope (Levine, 2005).

The goal of Project Portfolio Management is to ensure the correct alignment of budgets with organisations' strategic goals and a set of processes that intend to impose discipline and visibility to investments. Project data are collected, organised and modelled for the purpose of decision making and assuring that spending is aligned with the organisation's goals (Gardiner, 2005). The multidimensional concept of project portfolio management isn't constricted to the initial selection of projects. Moreover, it involves execution of projects that are firmly aligned with the strategies and resources of the organisation (Levine, 2005). The main difference between programme and portfolio is that a programme focuses on common outputs; while project portfolio shares the same inputs and resources (Turner, 2009).

Project-oriented organisations are highly complex organisations because of their dynamic boundaries and contexts. On the one hand, the number and the size of projects and programme s are constantly changing, permanent and temporary resources are utilised, and the organisations are structured in virtual teams and environment (Williams, 2002) (Baccarini, 1996). On the other hand, varying strategic alliances that are established that associated with different social environments of different projects and programme s and those environments continue to become more complex and chaotic (Geraldi, 2007). The way to succeed in such environments will be through a proper understanding of the landscape of complexity.

In real life, the management of a project is not about starting a specific task according to the project schedule or keeping the risk well captured in Risk Registrar and there is no surety that communications will always happen to follow project Communications Plan. Nevertheless, Programme Management is not a collection of projects managed together to achieve a targeted profit, which will only be controlled if projects were managed independently.

While project management is centered on achieving definite objectives, programme management aims to achieve the strategic objectives and goals of the incorporated programme. Each project should be executed by a project manager using a codified management approach. The overall programme will be executed by a Programme Manager who will be responsible for gathering the information about the progress of the projects and ensuring that the overall programme is aligned with the business objectives. This involves the ability of each of the project managers to manage the projects in such a manner that it facilitates the integration into a programme plan. Furthermore, they should be able to follow and evaluate the progress across the whole programme keeping in view the factors of risk management for each individual project as well as the entire risk across the programme. The managers should have the ability to monitor and frequently re-evaluate the risk and the same applies to quality management and cost management (Gardiner, 2005; Levine, 2005).

One of the recognised ways of understanding projects is a typology which describes the interaction of uncertainty and technical difficulties. Understating what to do (Outcomes) and how to do it (Processes), as shown in Figure 2-1.When the scope of projects is certainly defined and technically simple Traditional project management works fine which is known as Closed or painting by numbers. The second type of plan involves those projects where the outcomes and objectives are clearly defined but the process to achieve them is uncertain, semi-closed or going on a quest. The third type is where the project tools and processes are well defined, but the project outcomes are uncertain like making a movie which is called semi-open projects. The last types of projects are the ones where neither outcome nor processes are clearly defined and known. This type of projects should be cautiously progressed, frequently re-planned and have a regular check of outcomes exactly of what is done when lost in the fog. As the projects become more uncertain and vague, the more important the project methodologies and tools become for achieving success. This typology was developed by Eddie Obeng in the Project Leader's Secret Handbook (Obeng, 1994).

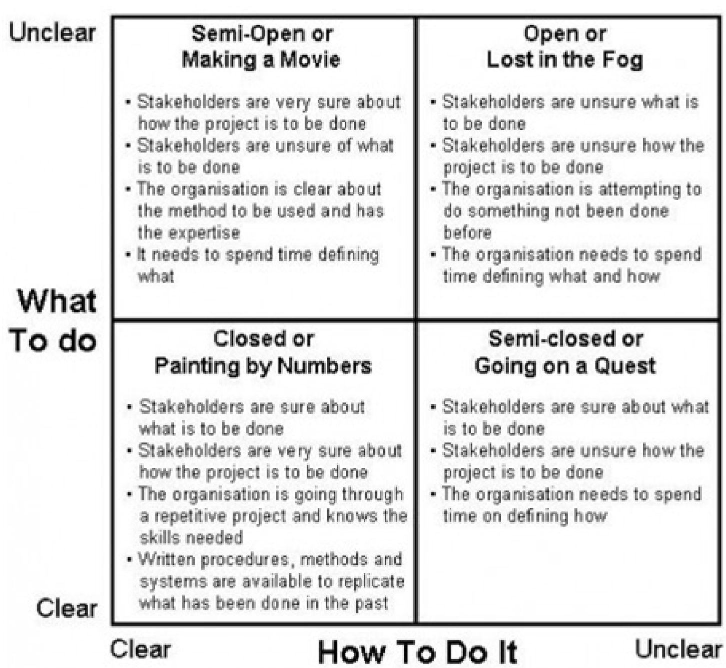


Figure 2-1 [Project Typology (Obeng, 1994)]

Both the Association for Project Management (APM) in the UK and Project Management Institute (PMI) in the USA suggest that most organisations have one or more portfolios of projects with each portfolio consisting of diverse programme s and projects. Programme management is concerned with the coordination of dependent or related projects to deliver benefits to organisations while projects are concerned with efficient delivery of outcomes. Subsequently projects will be carried out to create a targeted deliverable or outcomes and then clogged programme s will be carried out to create a change and encompass benefits for the entire organisation when adapting to environment is desirable and when using projects to create individual deliverables within the overall matrix of the programme (Weaver, 2007; Harpum, 2010).

2.2. Strategy and Governance

Strategy consists of managerial analysis, decisions and acts to resolve performance of a corporation and sustain competitiveness. This firstly, consists of assessing the external and internal environment, initiating a strategy or plan that should be employed and then controlled and evaluated. The concept of strategic management stresses on supervising and assessing strengths, weaknesses, opportunities and threats in organisations and its programme s (Wheelen and Hunger, 2010). Based on the Strategic Management Model the route is divided into four steps:

I. Environmental scanning: where information is monitored and evaluated by conducting SWOT analysis.

II. Strategy formation: where long-term plans are developed with an aim to effectively manage the opportunities and threats based on organisations strengths and weaknesses. Mission statement, Objectives, Strategies and Policies are products of this phase which will guide organisation and teams through the implementation phase.

III. Strategy implementation: here all the phases will be put into action and will be reflected on programmes and procedures.

IV. Evaluation and control: after implementation of strategy it's needed to watch out for any triggering events within the internal or external environments that may stimulate a change in strategy (Wheelen and Hunger, 2010).

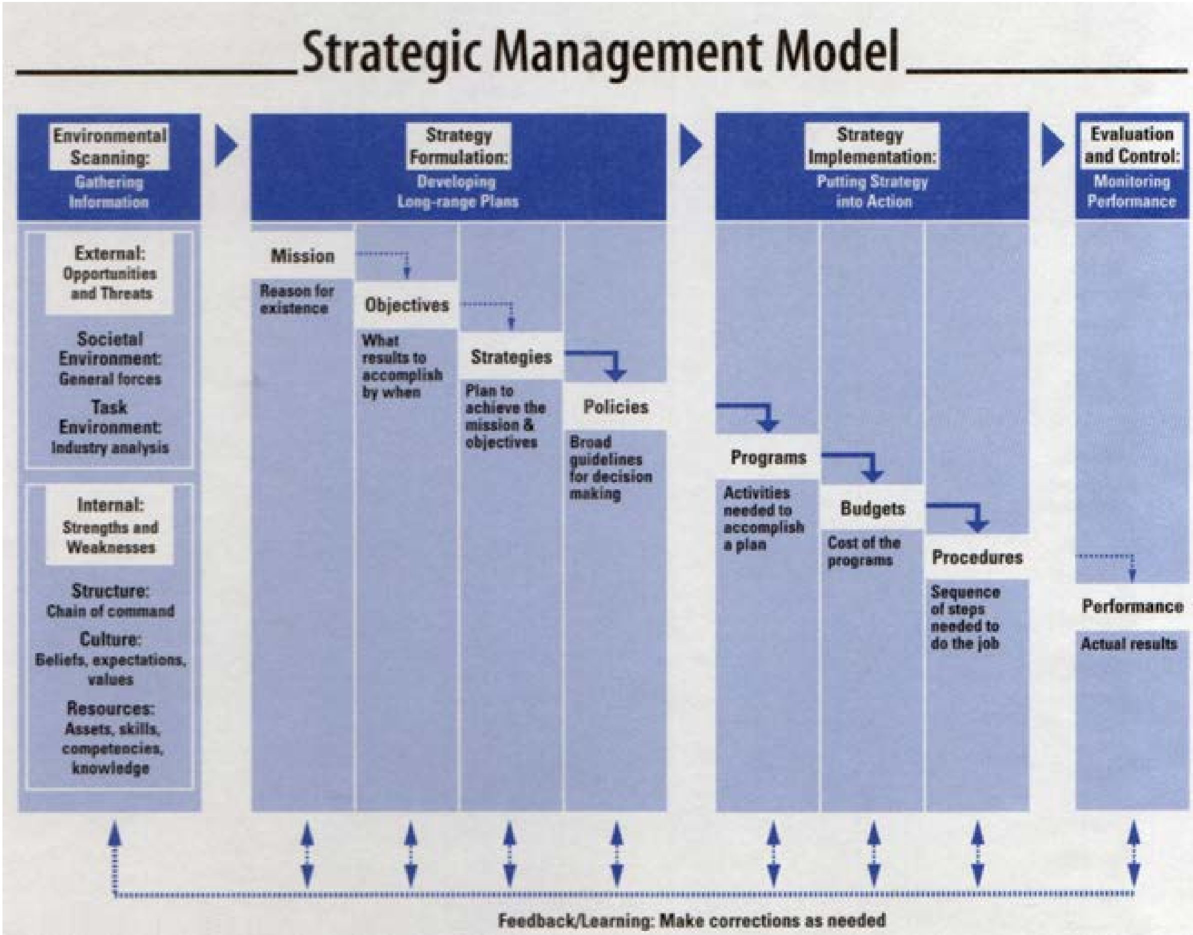


Figure 2-2 [Strategic Management Model (Wheelen and Hunger, 2010)]

Moving forward from strategy planning to resource based school where organisations resources are the fundamental determinant of competitive advantage. This approach assumes that a project within an organisation is heterogeneous with respect to resources that it controls. Moreover, the resource heterogeneity will continue over time due to the fact that resources are not entirely flexible across firms although these resources provided foundation for organisations competitive advantage along a continuum of specialized to general ones. It has become clear that when organisations penetrate into certain markets they enter according to similarity in products rather than similarity in resources (Collis and Montgomery, 2004).

Figure 2-3 [The Triangle of Corporate Strategy (Collis and Montgomery, 2004)]

This resources continuum is significant since it will limit organisation preferences, competition and perimeters. Figure 2-3 illustrate organisations strategy leverages of systematically controlling the businesses and effectively coordinating the resources to enhance market competitive advantage. Projects that are commenced as a result of organisation strategy nourish organisations momentum. However, this also leaps beyond the tradition of achieving strategic objectives to be facilitators for strategic initiatives (Crawford, 1998) but a distinction needs to be made; is it the Organisational strategy implemented by projects and programmes or is it the translation into programme or project strategy that is causing more complication. Many organisations experience disassociation between project strategy and organisation strategy plus lack of systematic approach to align them. This will form a major source of projects failure as well generate a barrier to maintain competitive advantage (Morris and Jamieson, 2004).

According to researchers, project management forms processes, procedures and tools that create linkages between project management practices and organisation practices (Heerkens, 2007). While examining different strategic project management models, all agreed on the alignment of project strategy with Organisational strategy and also agreed that portfolio management is an important requisite for strategic project management. Furthermore, Heerkens (2007) added the importance of programme management and key performance indicators (KPIs) while Green (2005) and Wessels (2007) highlighted the significance of competencies and capabilities in addition to benchmarking them with competitors. Furthermore, they adopted the resource based view while Heerken emphasized on strategy planning.

Challenges for strategic management in general and project management in specific are global due to the interaction of markets and organisations at international level, adoption of electronic commerce and the use of the internet for conducting business transactions. These activities force the organisations to hand over more authority to consumers and stakeholders. Furthermore, the pace of conducting business has radically increased (Galliers and Leidner, 2003). These challenges compelled organisations to become learning organisations and forced them to adapt the changes in the environment (Senge, 1990).

Governance is the framework of decision making while accountabilities and responsibilities are allied with an organisation's governance policy. Therefore, the role of governance is to provide a rational and robust decision-making framework to govern and guide an organisation to achieve the developed strategies. In order to accomplish this goal, an organisation should engage itself with the stakeholders, align decisions effectively with the strategy and ensure transparency of decisions and reporting (Garland, 2009). Moreover, Garland stated four principles for effective governance:

i. Guarantee leadership accountability for the success of the project.
ii. Focus on Service delivery ownership within project governance framework.
iii. Become effective in project decision making.
iv. Separate project governance from organisation governance structures to facilitate the project decision making process

With an understanding of the risks and rigidity of governance with current technologies and infrastructures, the need to deploy new strategy becomes a necessity. In another study, Levy (1994, 2000, and 2012) supposed some limitations and implications of complexity theory in strategies since it will be difficult to make long term planning due to nonlinearity, extreme sensitivity to initial conditions and interactions with the internal and external systems. Also, huge outcome can be achieved due to small changes and vice versa. Hence, rather than wasting the resources to forecast unpredictable behaviours and outcomes, organisations should emphasize on flexibility and creativity. They should be more adaptive and innovative in the highly complex environment and attempt to design patterns with short term predictability. However, the researcher concedes that complexity cannot simply be imported from natural science and be implemented in organisations and firms.

2.3. Embracing Complexity Theory and Emergence in Projects

All scientific theories are narrow and approximate as they never give comprehensive and definitive understanding of phenomena under investigation, since the web of networks will spawn feedback loops that will regulate system behaviours. This perception was sponsored by cybernetics in the early seventies by looking at the structures of behaviours in self-organised systems. Later, during the nineteenth century, mathematical models were developed to model natural phenomena. However, it was marked as Linear equations (Newtonian equations); nonlinear equations were not considered as complete nonlinear versions. In fact, nonlinear systems in topological features have chaotic (strange) and non-chaotic attractors. Analyzing the system by studying system`s attractors will create a dynamic picture of the whole system (phase portrait) to identify the structures and pattern of systems (Capra, 1996).

Complexity theory attempts to depict non-Newtonian facts that systems and environments are clustered around the edge of chaos where things are far from equilibrium. This state leads not only to disrupt the linearity of systems but over the span of time due to uncertainty, it causes the systems to become fragile. This explanatory framework provides an understanding of how organisations perform and how teams and organisations interact with larger environments. As a start-up, it is important to outline interpretations of complexity and key complexity terminologies in order to establish a base for complexity employment in the field of Project and Programmes Management.

2.4. Complexity Definition and taxonomy

A considerable amount of literature has been published on complexity. These studies vary in defining complexity and its classifications, applications and limitations. In order to understand the difference between these studies, it should be found out how it defines complexity itself. Depending on each researcher's background, complexity can be interpreted broadly and taken as a metaphor or an analogy or even literally applied in systems.

"Complexity refers to the condition of the universe which is integrated and yet too rich and varied for us to understand in simple common mechanistic or linear ways.

We can understand many parts of the universe in these ways but the larger and more intricately related phenomena can only be understood by principles and patterns - not in detail.

Complexity deals with the nature of emergence, innovation, learning and adaptation."

(Santa Fé Institute, herman & Shultz 1998 p. 63)

Complexity Theory is concerned with studying order that emerged from chaos. In another words complex behaviour emerges from simple rules that govern interacting parties with dynamic systems. So it tends to study few major characteristics of the complex system:

1. **Interconnected and interdependent** agents and scope: it is a key principle of complexity since it implies that any agent response or behavior is affected by other connected and dependent agents and will not have the same impact with time.
2. **Dynamic**: complex systems are dynamic and they will change over time. Even some literature call them Dynamics of Complex Systems (Bar-Yam, 2003)
3. **Multiplicity**: it is a signature result in many possible outcomes, providing it with the capacity to choose, explore and adapt.
4. **Nonlinearity**: A key variable that initiated change in random, unpredictable way and involves discontinuities. A slight variation will result in catastrophic changes and outputs as the variables are not related linearly.
5. **Feedback**: In a complex system, it could be obtained in both negative and positive feedback. The outputs of an agent are returned to other agent input and the effect could be counter-intuitive.
6. **Emergence:** As a result of simple rules of interaction: this aspect of complex system makes it so unique and what makes researchers interested in complexity other than chaos. This notion challenges the controlled order by creating new patterns through natural self-organized order.
7. **Radically Unpredictability**: Prediction is impossible in complex system because of this exponential nonlinearity in outcomes.
8. **Sensitivity to initial condition:** also known as "Butterfly effect" points out to situations where small changes have the ability to make huge impacts. This concept was coined by Edward Lorenz in 1961 during work on weather prediction modeling he entered 0.506 instead of 0.506127 and result was a completely different weather scenario. This idea was expressed in a paper presentation American Association for the Advancement of Science "*Does the flap of a butterfly's wings in Brazil set off a tornado in Texas?*"
9. **Self-organisation and co-evolution**: Based on this principle a complex system can co-evolve and co-create a new environment. Best examples in self organisation can be seen in nature in ants, bees and birds flock where they have

been organized in remarkable emergent behavior to deliver targeted outcomes to the individual, the group and system.

10. **Sociotechnological and Socioeconomical aspect**: These principles were coined to recognise the interaction between society and technology or society and economy underlining its duality both people-centric and technical-centric (Sussman, 2010).

The Debate spectrum of literature and research within the complexity science and systems highlight multiple definitions of complex systems and system complexity. Seth Lloyd the MIT complexity researcher, claims that he encountered over three dozen different concepts of complexity even when he was asked to describe complexity said: "*I can't define it for you, but I know it when I see it.*"

The definition of complexity "consist of interconnected or interwoven part" (Bar-Yam, 1997) so the behavior of the system can simply be understood by studying the whole system behavior rather than understanding each part alone. This implies studying the part and its interaction to the other parts.

Peter Senge in the Fifth Discipline (1994) attempts to address failures to deliver business outcomes and poor handling of complexity where he interprets that lack of recognition between detail complexity and dynamic complexity. The detailed one refers to organisation's business information, tools, and methods in order to do the business, where the word dynamic refers to complexity in such a business where conventional tools failed to justify failures since cause and effect are subtle. Meanwhile, Hass sees the sources of complexity volume of details, lack of understanding of cause and effect especially at the execution phase, the unpredictability of outputs, and uncertainty of change (Hass, 2009).

Baccarini (1996) sees the importance of managing projects in complexity as he believes that it will identify planning and coordination in projects, aid in selecting projects Organisational structures, help in organising and setting projects' objectives, inputs and procurement process. Baccarini notes that projects complexity increases due to two major factors; Organisational structure complexity, such as vertical depending on the number of hierarchal levels or horizontal depending on the number of departments and department's specialities. The other factor is the technological aspect of projects which can be interpreted in terms of differentiation and interdependence.

Williams (1999, 2002) built his complexity dimensions on Baccarini`s definition of project complexity and out of the two major dimensions of structural complexity and uncertainty sub-dimensions are separated based on the number of elements and interdependence between elements structural complexity can be increased. Moreover, Williams believes that uncertainty can attribute to the complexity of projects then uncertainty of goals or methods became factors of project complexity.

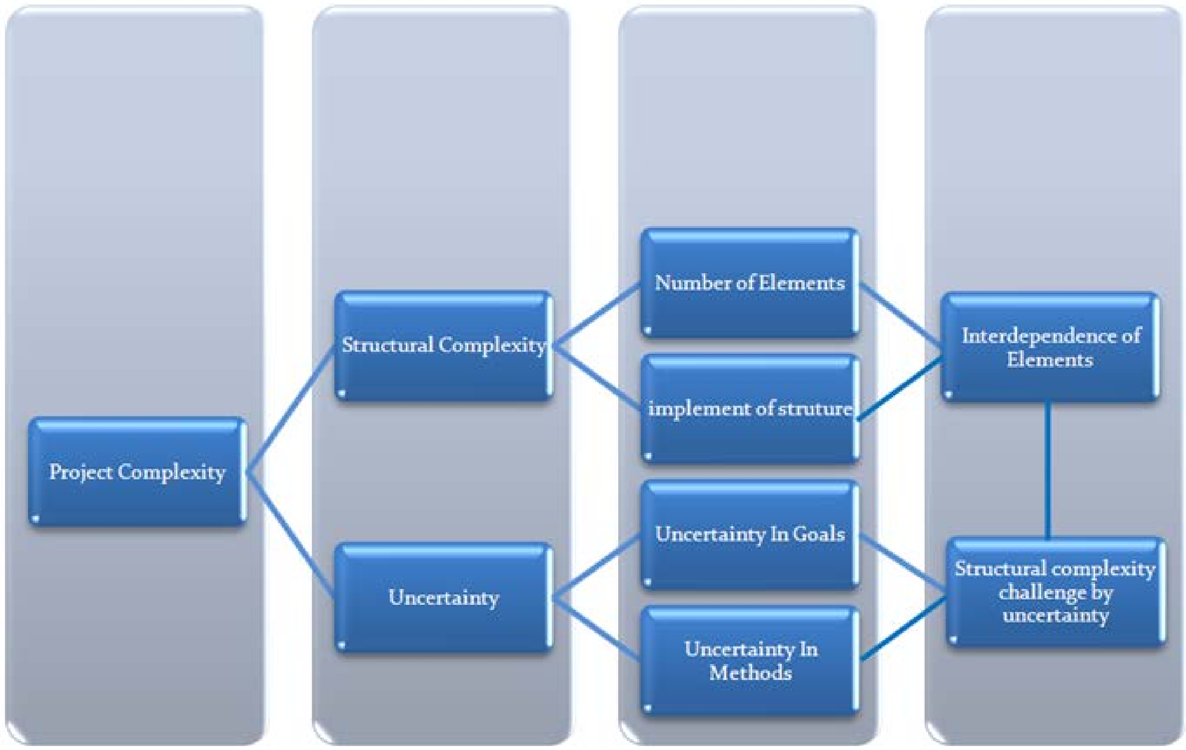


Figure 2-4 [Project Complexity dimensions and Sub-dimensions (Williams, 2002)]

In addition to Baccarini and Williams, Xia and Lee (2004, 2005) measured projects complexity in four dimensions: technological versus Organisational, and structural versus dynamic. This means that complexity in information systems development projects (ISDP) has a multi-dimensional nature. Based on this complexity taxonomy project performance and strategies will develop a framework for coping project complexities.

Xia and Lee stated that Organisational complexity when operated as project management control over limited resources, teams; knowledge and management support drastically the risk of efficient execution of project delivery in terms of time, cost and quality.

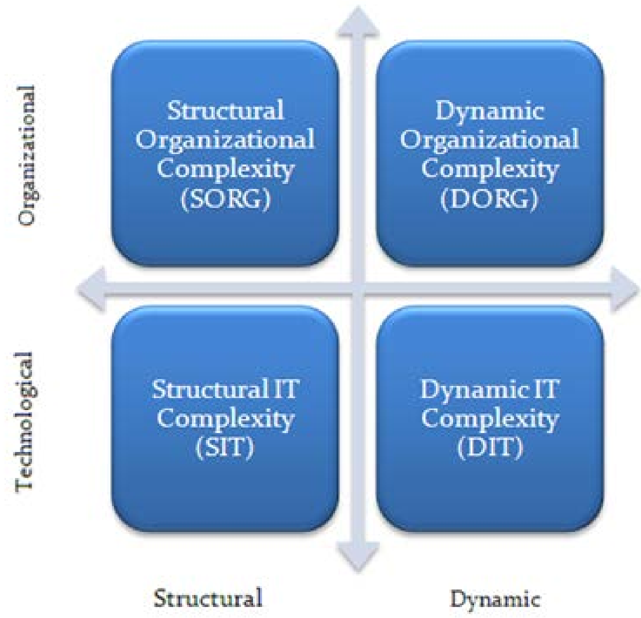


Figure 2-5 [A Conceptual Framework of ISDP Complexity (Xia, W., Lee, G., 2004, 2005)]

Then Geraldi and Adlbrecht (2007, 2009) further developed the Williams complexity dimensions and categorised complexity into three types: the complexity of fact which rises because of the structural dimension of complexity. The second type is known as the complexity of faith which rises with the course of dealing with news technology or a new product in which goals and methods are not broadly specified. Last the complexity of interaction, which occurs with the interactions between people and environments, including the softer aspects of projects like politics and cultures within projects.

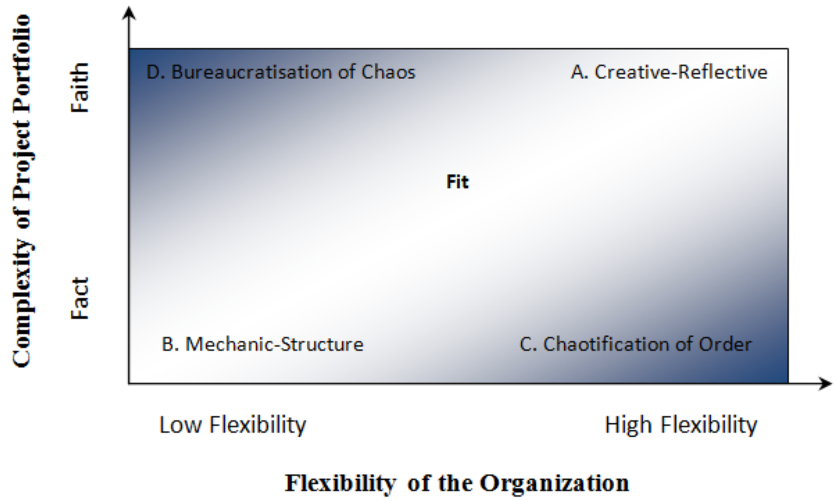


Figure 2-6 [Fit between Complexity and Flexibility (Geraldi and Adlbrecht, 2007)]

Geraldi suggests locating the Edge of Chaos as a combination between complexity and flexibility, where Complexity falls within faith or facts and Flexibility falls within high or low as expressed in figure 2-6 safe zone "fitness landscape". The organisation should locate its project within this landscape empowered by flexibility to face complexity. In order to manoeuvre uncertainty this is owed by non-linearity complicated technology, unclear scope and methods, and environmental changes. The uncertainty may be expressed Geraldi suggests locating the Edge of Chaos as a combination between complexity and flexibility, where Complexity falls within faith or facts and Flexibility falls within high or low as expressed in figure 2-6 safe zone "fitness landscape". The organisation should locate its project within this landscape empowered by flexibility to face complexity. In order to manoeuvre uncertainty, this is owed by non-linearity complicated technology, unclear scope and methods, and environmental changes. The uncertainty may be expressed as a loss of faith in the technology or method within the project and other stakeholder involved in the project (Geraldi and Adlbrecht, 2007).

Table 2-1 [Categories of Complexity (Geraldi and Adlbrecht, 2007)]

Fact	Faith	Interaction
▪ Size of the project	▪ Low level of maturity	▪ People
▪ Dependency of others departments	▪ New technology	▪ Company politics
▪ Dependency of other companies	▪ New partners	▪ Internationality
▪ Quantity of information analyzed	▪ New processes	▪ Multidisciplinary
▪ Quantity of sources of information	▪ Dynamic (changing information,	▪ Client
▪ Quantity of partner and contact ▪ persons	▪ Various and open options	

At the same time, Remington and Pollack (2007) have been working on tools for complex projects where they categorise complexity into the four famous classes or perspectives on complexity: Structural, Technical, Directional, and Temporal Complexity where structural and technical complexities raise within the project while temporal and directional complexities branched from projects environment.

Structural complexity

Most academics and practitioners agree that complex projects contain this complexity and some people may call it complicatedness. This complexity arises from interrelated and interdependent activities because of Organisational structure and interconnected processes. Yet it is believed that reductionist approach can be applied in this category of complexity.

Technical complexity

Technical complexity is a wide and unanimous complex since most of the tools, techniques, products and processes became a source of technical complexity in any business environment. In addition, the interdependencies between sources of technical complexity have the capability to lift up the level of complexity in projects.

Directional complexity

This category is characterised by unclear goals, methods and objectives. It maybe uncertain due to vague and hidden agendas, that creates potential misunderstanding and poor explanation of goals and methods. This will get worse in case of fierce relationships and Organisational politics within projects. Another source of directional complexity is a change in vision, goals and objectives during the project life cycle.

Temporal complexity

The primary source of this complexity is uncertainty, and this comes up from differences in environmental expectations which take place during the project life cycle especially in the development phase. The unpredictability of change or shift in organisation and environment over time due to the instability of the internal or external environment are the major symptoms for this complexity.

Table 2-2 [Categories of Complexity, Remington and Pollack (2007)]

Complexity	Complexity Source
Structural complexity	Uncertainty due to connections and interdependencies
Technical complexity	Uncertainty about how generate solutions
Directional complexity	Uncertainty about goals/goal paths
Temporal complexity	Uncertainty about change over the project life

Another report was prepared in 2007 to measure complexity in Global Alliance for Project Performance Standards (GAPPS) by using CIFTER (Crawford-Ishikura Factor Table for Evaluating Roles) based on competency standards for global level 1 and level 2 project managers. The report discusses seven project management complexity factor s each with a four qualitative point response scale.

1. Stability of the overall project during project life-cycle and environment.
2. Number of distinct disciplines, methods, or approaches involved in performing the project

3. Magnitude of legal, social, or environmental implications from performing the project
4. Overall expected financial impact (positive or negative) on the project's stakeholders
5. Strategic importance of the project to the organisation or organisations involved
6. Stakeholder cohesion regarding the characteristics of the product of the project
7. Number and variety of interfaces between the project and other Organisational entities

Table 2-3 [Crawford-Ishikura Factor Table for Evaluating Roles (CIFTER), 2007]

Project Management Complexity Factor	**Descriptor and Points**			
Stability of the overall project context	Very high	High	Moderate	Low/Very low
Number of distinct disciplines, methods, approaches involved in performing the project	Very high	High	Moderate	Low/Very low
Magnitude of legal, social, or environmental implications from performing the project	Very high	High	Moderate	Low/Very low
Overall expected financial impact (positive or negative) on the project's stakeholders	Very high	High	Moderate	Low/Very low
Strategic importance of the project to the organisation or organisations involved	Very high	High	Moderate	Low/Very low
Stakeholder cohesion regarding the characteristics of the product of the project	Very high	High	Moderate	Low/Very low
Number and variety of interfaces between the project and other Organisational entities	Very high	High	Moderate	Low/Very low

Summation of the score for all factors will be used to categorize the projects according to three levels of complexity in order to assess project manager roles and competencies:

$$Below\ G1\ where\ Complexity_{SUM} < 11 \Rightarrow \text{Project considered Simple}$$

$$G1\ where\ 11 \leq Complexity_{SUM} < 19 \Rightarrow \text{Project considered Complex}$$

$$G2\ where\ Complexity_{SUM} \geq 19 \Rightarrow \text{Project considered very Complex}$$

As shown in Table 2-3 the four descriptor or score points are subjective but the consistency in the project assessments could facilitate its use to differentiate and compare project management and project complexity. However, some of the factors are overlapping and are interconnected. It is a guide intended to match the project complexity and the skill of a project manager (GAPPS, 2007; Duncan, 2006).

In order to regulate programmes typology, GAPPS developed framework shown in table (2-4) which is intended to support the development of standards recognition of transferring programme qualifications. This framework map all standards targeting to understand the requirements for dealing with challenges based on programme characteristics and types (GAPPS, 2011).

Table 2-4 [GAPPS Programme Typology (GAPPS), 2011]

Programme Characteristic	Strategic Programme	Operational Programme	Multi-project Programme	Mega-project
General Purpose	Deliver assets and benefits that are directly linked to attaining the sponsoring organisation's desired future state	Deliver assets and benefits that are critical to the sponsoring organisation's day-to-day operations	Achieve synergies from projects with common traits such as shared resources, similar clients, or product technology	Deliver a specific asset to the sponsoring organisation
Key Differentiating Feature	Link to a specific business goal or strategic initiative	Relative interdependence of constituent projects	Relative independence of constituent projects	Significantly larger than the sponsoring organisation's typical projects
Reason for Grouping Projects	Early results influence Decisions about later projects	Minimize negative impact on ongoing operations	Benefits expected from synergy	So much larger than the organisation's typical projects

In another study Maylor, Vidgen and Carver (2008), attempted to understand what makes a project complex to manage entitled Managerial Complexity in Project-Based Operations: A Grounded Model and Its Implications for Practice based on a study of the telecommunications sector, defence sector and a transportation sector. In the paper, they came up with a qualitative model to assess structural and dynamic dimensions of managerial complexity in projects in which structural complexity is split in five sub-dimensions MODeST (Mission, Organisation, Delivery, Stakeholders and Team).Under each dimension, several concepts branched per dimension. Furthermore, dynamic dimension has the ability to interact or sprout from every structural element of the model. This debate keenly looks to figure out what really makes projects tough to manage.

MODeST dimensions shown in Figure 2-7 characterize managerial complexity into sub-dimensions that may interact and cause managerial complexity to increase, also each dimension or sub-dimension could change over time which made the model capable of capturing managerial, dynamic and interacting complexities (Maylor et al., 2008).

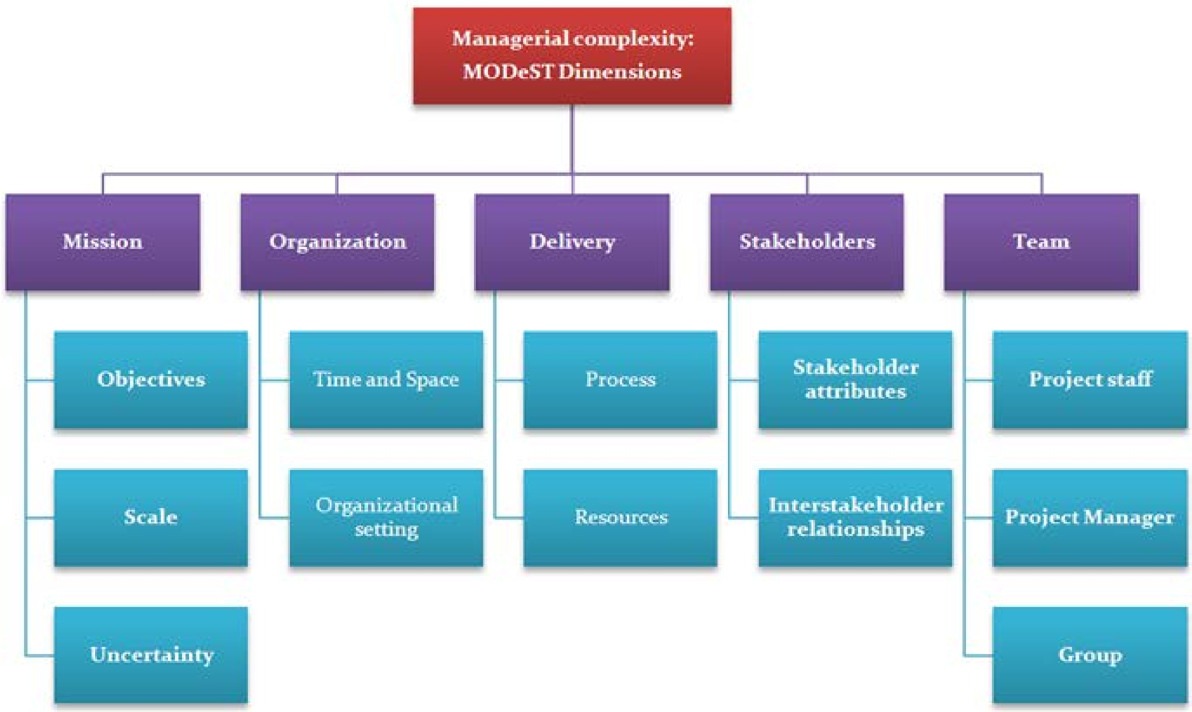


Figure 2-7 [Dimensions of Managerial Complexity (Maylor, Vidgen, and Carver, 2008)]

Kathleen Hass put an expensive effort in her project complexity model that identifies projects complexity and finds out relevant complexity dimension(s), in addition, it decides on appropriate management approaches. In her research, project complexity was caused by project details, ambiguity, uncertainty, unpredictability, dynamics, social structure, and interrelationships. The model divided complexity into nine dimensions (Hass, 2009):

1. Size/Time/Cost
2. Team composition and past performance
3. Urgency and flexibility of cost, time, and scope
4. Clarity of problem, opportunity, solution
5. Requirements, volatility and risk
6. Strategic importance, political implications, stakeholders
7. Level of change
8. Risks, dependencies, and external constraints
9. Level of IT complexity

The Table 2-5 represents an illustration that can help identify project complexity. The shaded boxes in the table express the level of complexity. As a result, a project's complexity may be presented graphically as a spider chart as in figure 2-8 to communicate the project complexity aspects.

Table 2-5 [Project Complexity Model, (Hass, 2011)]

Complexity Dimensions		Project Profile			
		Independent Project	Moderately Complex Project	Highly Complex Project	Highly Complex Programme "Megaproject"
Size/ Time/ Cost	Size:	3–4 team members	5–10 team members	> 10 team members	Multiple diverse teams
	Time:	< 3 months	3–6 months	6 – 12 months	Multi-year
	Cost:	< $250K	$250–$1M	> $1M	Multiple Millions
Team composition and past performance	PM:	Competent, experienced	Competent, inexperienced	Competent; poor/no experience with complex projects	Competent, poor/no experience with megaprojects
	Team:	Internal; worked together in past	Internal and external, worked together in past	Internal and external, have not worked together in past	Complex structure of varying competencies and performance records (e.g., contractor, virtual, culturally diverse, outsourced teams)
	Methodology	Defined, proven	Defined, unproven	Somewhat defined, diverse	Undefined, diverse
	Contracts:		Straightforward	Complex	Highly complex
	Contractor Past Performance		Good	Unknown	Poor

Urgency and Flexibility of Cost, Time, and Scope	**Scope:**	Minimized	Achievable	Over-ambitious	Aggressive
	Milestones:	Small	Achievable	Over-ambitious, firm	Aggressive, urgent
	Schedule/ Budget:	Flexible	Minor variations	Inflexible	Aggressive
Clarity of Problem, Opportunity, Solution	**Objectives:**	Defined and clear	Defined, unclear	Defined, ambiguous	Undefined, uncertain
	Opportunity/ Solution:	Easily understood	Partially understood	Ambiguous	Undefined, groundbreaking, unprecedented
Requirements, volatility and risk	**Customer Support:**	Strong	Adequate	Unknown	Inadequate
	Requirements	Understood, straightforward, stable	Understood, unstable	Poorly understood, volatile	Uncertain, evolving
	Functionality:	Straightforward	Moderately complex	Highly complex	Many complex "functions of functions"
Strategic Importance, Political Implications, Stakeholders	**Executive Support:**	Strong	Adequate	Inadequate	Unknown
	Implications:	None	Minor	Major, impacts core mission	Impacts core mission of multiple programmes, organisations, states, countries; success critical for competitive or physical survival
	Communications	Straightforward	Challenging	Complex	Arduous
	Stakeholder Management:	Straightforward	2–3 stakeholder groups	Multiple stakeholder groups with conflicting expectations; visible at high levels of the organisation	Multiple organisations, states, countries, regulatory groups; visible at high internal and external levels

Level of Change	**Organisational Change:**	Impacts a single business unit, one familiar business process, and one IT system	Impacts 2–3 familiar business units, processes, and IT systems	Impacts the enterprise, spans functional groups or agencies; shifts or transforms many business processes and IT systems	Impacts multiple organisations, states, countries; transformative new venture
	Commercial Change:	No changes to existing commercial practices	Enhancements to existing commercial practices	New commercial and cultural practices	Ground-breaking commercial and cultural practices
Risks, Dependencies, and External Constraints	**Risk Level:**	Low	Moderate	High	Very high
	External Constraints:	No external influences	Some external factors	Key objectives depend on external factors	Project success depends largely on multiple external organisations, states, countries, regulators
	Integration:	No integration issues	Challenging integration effort	Significant integration Required	Unprecedented integration effort
	Potential Damages:	No punitive exposure	Acceptable exposure	Significant exposure	Unacceptable exposure
Level of IT Complexity	**Technology:**	Technology is proven and well-understood	Technology is proven but new to the organisation	Technology is likely to be immature, unproven, complex, and provided by outside vendors	Technology requires ground-breaking innovation and unprecedented engineering accomplishments
	IT Complexity:	Application development and legacy integration easily understood	Application development and legacy integration largely understood	Application development and legacy integration poorly understood	Multiple "systems of systems" to be developed and integrated

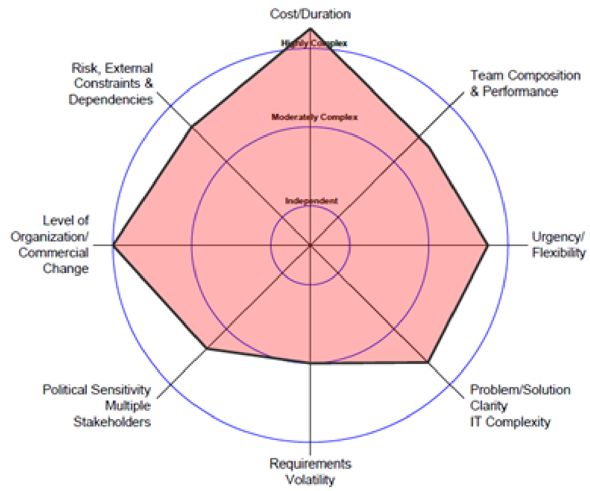


Figure 2-8 [Overall Project Complexity (Hass, 2009)]

Therefore complexity thinking maybe applied to projects and programmes by selecting suitable methods and approaches, assigning project leadership and project life cycle based on the project complexity dimensions, and building complex, adaptive solutions (Hass, 2009).

Loch et al. (2011) adopt three factors cause complexity in project: Technical complexity results for many systems interdependency among the project, Actor complexity caused by stakeholders interference results in different project dimensions and targeting contradictory outcomes. Also External complexity is the last factor in project level which resulted by running projects in different markets or environments which will create diversity in regulations, standards and competition. Once this view focus in project portfolio new complexity dimensions become visible or have a different effect; Technical complexity interaction may result in positive or negative interaction based on the functionality in the other projects, same applies for resource, Market, and External interactions (Cooke-Davies et al., 2011).

The recent group of researches tries to endeavour and study methods plus conceptual models which deal with one or several complexity factors. Vidal et al. (2011) developed a framework in order to measure project complexity using an Analytic Hierarchy Process through pair-wise comparisons then complexity is determined, based on project size, interdependencies, variety, and context-dependence. Delphi Technique utilised to build criteria and factors using case studies the authors keep that the resulting complexity index overcomes the limits of existing complexity (Vidal et al., 2011).

Rekveldt et al. (2011) classified a number of elements contribute to complexity which then clusters into: Technological, Organisational and Environmental which is known as TEO framework, this framework built based on wide range of literature and case studies. It contains 50 elements 40 out of the different studies plus 10 from case studies. It reproduces the structural elements identified by Baccarini(1996) Xia and Lee (2004) and the Technical elements and some of Organisational elements by Williams (2002) Xia and Lee (2004), additionally uncertainty and risk influence will be seen and shape in the three categories based on Taleb (2007) Hillson and Simon (2007). The last category is the Environmental is the main addition of the TOE model over previous frameworks. Table 2-3 shows Rekveldt view of complexity plus subcategories that will be also divided into 50 elements related to the 14 subcategories.

Figure 2-9 [Categories and Subcategories of TOE, (Rekveldt et al., 2011)]

Same year Xian and Xue-qing built the Construction System Complexity Concept Model (CSCCM) which is represented in three dimensions:

1. Definition dimension,
2. Character dimension and
3. Perspective dimension: which is made of six project complexity angles: Engineering technology complexity, stakeholders' complexity, task complexity, information complexity, objectives complexity and environment complexity (Xian and Xue-qing, 2011).

Later some studies as one by Robert Chapman try to establish a framework for examining the dimensions and characteristics of complexity inherent within rail megaprojects. The framework seeks to set a complex decision-making process linked to the implementation of the megaproject that will establish the great transport network of the United Kingdom, due to the large number of environmental, social and political variables that must be taken into account. It suggests construction of a model supported in pre-existing projects ranging from the simple to the complex, as a tool for decision-making. It should be noted that complexity will be used to analyse all aspects related to the project life cycle (Chapman, 2016).

In more recent published work a complicated study illuminates theoretical implications and analyses to create a model that relates to the levels of complexity within projects. As an alternative of proposed the dimensions of project complexity identified based on projects or environment characteristics, they recommend three levels of project complexity can be evolved; this will direct how a project can be categorised:

1. Projects as Complicated Systems
2. Projects as Complicated Systems in Dynamic Environments
3. Projects as Complex Adaptive Systems

Those categories coupled with proposed three-tier dimensions of complexity formed the fundamental attributes of projects and its environment. Based on this view attributes of projects linked to the structural, interactional, and dynamic dimensions of complexity. This will result in the allocation of projects complexity level and improved interpretation as Complicated Systems, Complex Systems, or Complex Adaptive Systems (Kiridena et al., 2016).

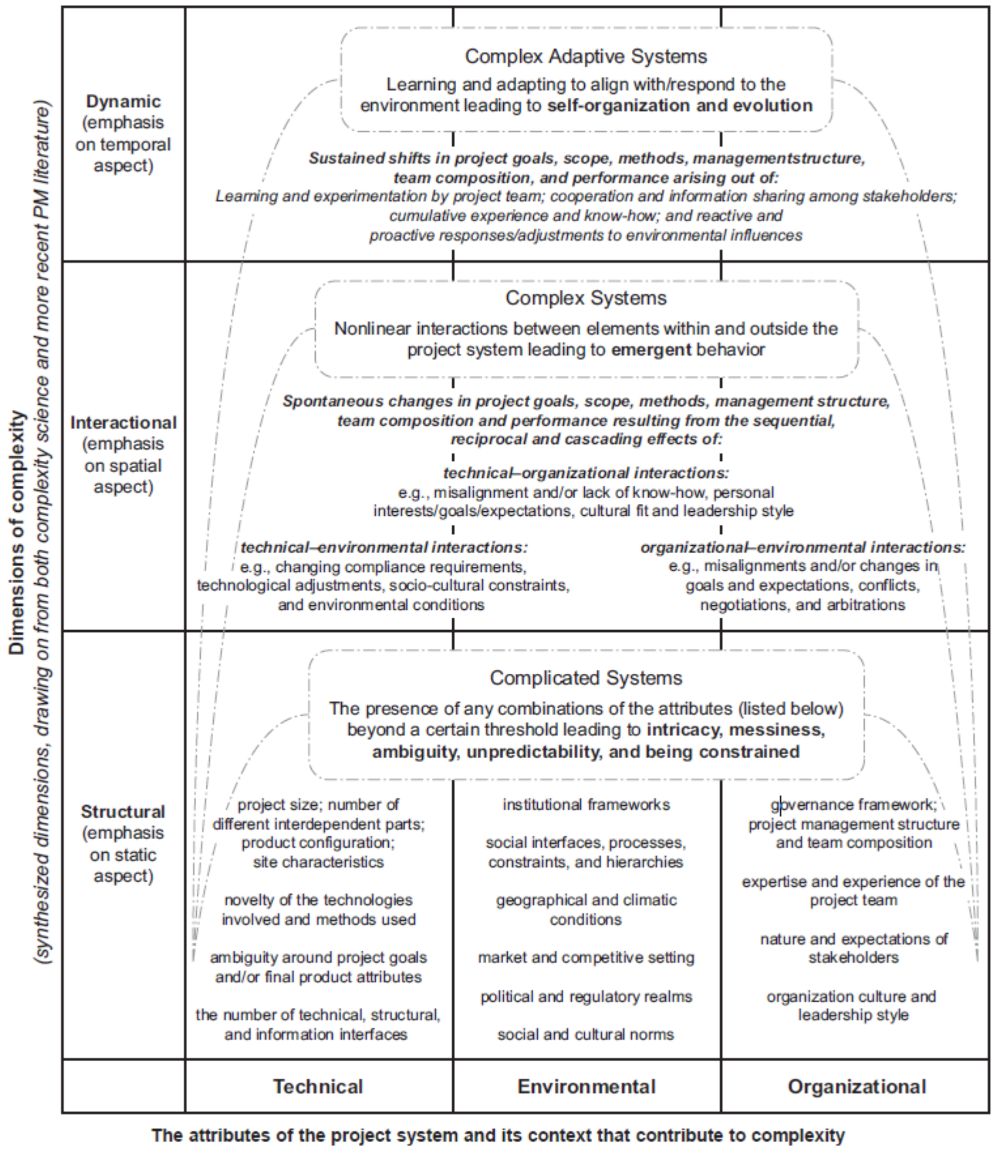


Figure 2-10 [Project Complexity Framework, (Kiridena et al., 2016)]

2.4.1. Summary of Complexity types in Project Management

Because of the perplexity in delineating project complexity amongst project management academics and practitioners many studies and published papers end this dilemma. Most research and literature agree on the main components of projects complexity associated with interconnections and interdependences of organisation structure and technologies.

Studying projects complexity is linked to the aspects that cause it. Baccarini (1996), Williams (1999), Remington et al. (2007) and Maylor et al. (2008) categorise it according to two types of complexity; Organisational and technological, considering the understanding of projects holistically and not only the specific components. Since the studying part response isn't necessarily representing the whole, all of them expect Baccarini added uncertainty consideration in complexity categorisation.

Project complexity model developed by Williams mainly focuses on the technical aspects and then the Organisational aspects. Although environment, stakeholders and all the elements interdependency are considered to be the components of structural complexity, the aspect of uncertainty is attached to goals and the methods required for achieving those goals to create structural complexity integrated within the environment of uncertainties. This model reflects softer aspects whereas social complexity seems to have overlaps within the organisational complexity and the environment (Williams, 2002).

While Geraldi and Adlbrecht (2007) consider complexity as a natural aspect of projects that can be developed they categorized it in three different types: a) related to structure interdependency (Complexity of Fact) b) related to uncertainty (Complexity of Faith) lastly c) related to the interfaces between people and systems (Complexity of Interaction). CIFTER heavily considers the impact of the project on the organisation from the prospective of stability, financial, strategic and project implications. As a result concentrates on the interaction between project and the environment (political, economic, social, legal,), plus take into consideration the technical aspect with a broad focus on the interaction between the project and the business environment.

Technical-Organisational -Environmental framework Rekveldt et al. (2011) developed a categorisation framework it overlooks typological aspect of complexity like level which a factor evolves the overall complexity. Nevertheless, the framework replicates many of the major features identified by most researchers with some additions in environment sub-categories.

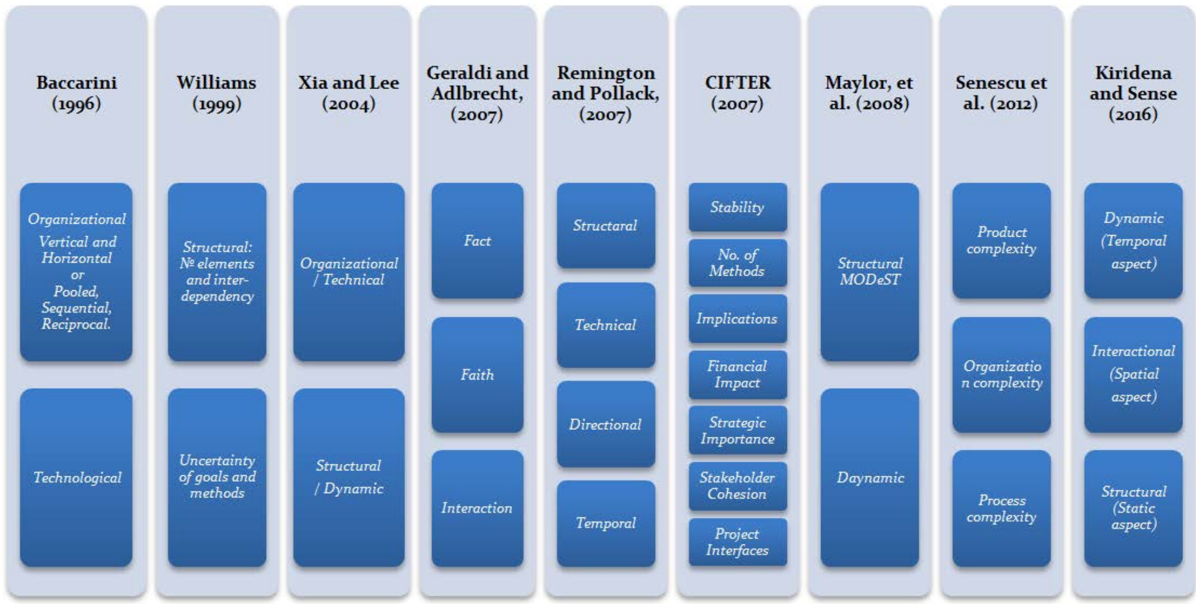


Figure 2-11 [Summary of Complexity types in Project Management]

Obviously, the Organisational complexity and project success were proven to be the main factor than the technical complexity in projects (Baccarini, 1996; Williams, 1999; Xia and Lee, 2004; Remington et al., 2007; Maylor et al., 2008; and Cooke-Davies et al, 2011). Gradually the social interactions, including the role of communication and power, have become the primary focus and an important source of complexity. Further perceptions of complexity identified stakeholder power and inter-stakeholder relationships as a source of complexity (Maylor et al, 2008).

However, complexity is more than just showing several aspects including nonlinearity, continuous interactions with the environment, emergent behaviour and feedback loop. Complexity is generally difficult to measure or even quantify its interactions and consequences as they are not well understood nor do the tools exist that are explicitly intended to help in identifying and managing these complexities (Cooke-Davies et al., 2011).

Factors that contribute to project complexity share the uncertainty owed by non-linearity, Complicated technology, unclear scope and methods, and environmental changes. The uncertainty may be expressed as a loss of faith in the technology or method within the project and other stakeholder involved in the project (Geraldi and Adlbrecht, 2007).

Other factors that contribute to the project include poor communication, poor motivation, poor relationship management and unclear distribution of responsibilities, as well different cultures and languages that impact project success. Different cultures result in diverse assignments that are more or less importance to absolute success and failure factors (Ojiako et al., 2012; and Geraldi and Adlbrecht, 2007).

Table 2-6 [Projects complexity factors taxonomy]

Projects complexity factors taxonomy	Baccarini	Williams	Xia and Lee	Geraldi and Adlbrech	Remington and Pollack	CIFTER	Maylor et al.	Senescu et al.	Kiridena and Sense
Uncertainty in scope & goals	◆	◆	◆	◆	◆	◆	◆	◆	◆
Uncertainty in methods		◆	◆	◆	◆	◆		◆	◆
Goals alignment & Clarity		◆	◆	◆	◆	◆	◆	◆	
Technical complexity & Team competency	◆		◆		◆	◆	◆	◆	
Risk & Leadership	◆	◆		◆	◆	◆		◆	◆
Project environment & stability		◆	◆	◆	◆	◆	◆		◆
High interdependence in the project	◆	◆	◆				◆	◆	◆
Multidiscipline in projects	◆	◆	◆	◆	◆	◆		◆	◆
Different cultures & languages				◆			◆	◆	◆
Communication aspects	◆	◆	◆		◆	◆		◆	◆
Size Vs Resources and teams	◆	◆	◆	◆		◆	◆	◆	
Stakeholders influence			◆	◆		◆	◆	◆	◆

2.4.2. Projects complexity and uncertainty

As discussed in the studies above on project complexity was mainly caused by uncertainties. Subsequently improving the way of dealing with uncertainty will improve the methods and approaches used to manage complex projects. Traditional risk management scholars assumed risk is the same as uncertainty, majority of academic society recognise that risk as one of the implications of uncertainty (Williams, 2002; Xia and Lee, 2004; Geraldi and Adlbrecht, 2007; Remington and Pollack, 2007; Maylor et al., 2008; Hass, 2009; and Cooke-Davies et al., 2011). Hillson and Simon consider risk has a positive and negative side in their definition of risk “any uncertainty that, if it occurs, would have a positive or a negative effect on the achievement of one or more objectives” (Hillson and Simon, 2007).Project risks have two components; the probability of the event and the impact of the event. Nevertheless when ranking risks, splitting the impact and probability helps to decide which risks taking and which risks are to be mitigated. Nevertheless, risks may change during the project life cycle. As a result of actions to mitigate project risk, new risks might arise (secondary risks) and some risks might remain (residual risk) (Hillson & Simon, 2007).

Uncertainty typically tends to have negative penalties on project complexity. Furthermore, project complexity could become a source of uncertainty, thus making a difference between real project status and supposed project status “mental models”. This variance normally happened due to personal perception of the project reality, or due to the fact complexity implies projects cannot be totally understood. (Jaafari, 2003)

Although some authors have described project uncertainty in terms of the technological or environmental setting, others have offered general characterisation where the variables and their relationships are unknown. This necessitates changing mental models to risk and uncertainty. Consequently, uncertainties do not only represent threats but also might represent opportunities (Schrader et al., 1993).

Successively project management methods and tools necessarily should consider the uncertainty aspect of the project, as measured along four dimensions of uncertainty:

i. Variation
ii. Foreseen uncertainty
iii. Unforeseen uncertainty
iv. Chaos or turbulence.

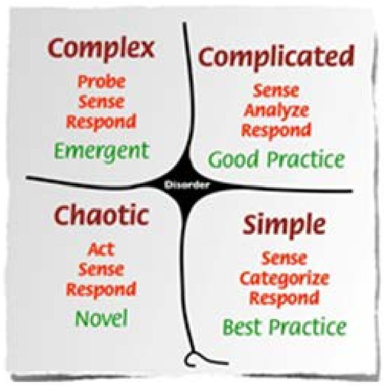
Variation in costs, time and performance of resources is the main source of project uncertainty. Then foreseen uncertainties are recognised yet their effects on projects are uncertain, while on the other side unforeseen uncertainties are not fully recognised in the planning phase, as a result of this there is no proper plan for considering the ways to handle such uncertainties. This situation makes contingency planning difficult if not impossible. Finally, chaos or turbulence uncertainties refer to uncertainty about the project itself that make the project plan unclear and unknown mainly in radical R&D projects, this required flexible approaches and well established feedback setup (De Meyer et al., 2001).

Williams (2005) divided uncertainty to foreseen uncertainty “known unknowns” which manageable by contingency plans, while the unforeseen uncertainty “un known unknowns” not possible to plan it or even move it from unforeseen domain to the foreseen zone (Williams, 2005).

2.4.3. Complex(ity) systems Related Views

Complex, large-scale, integrated, open systems or what is called CLIOS was first discussed by Joseph Sussman (2010) while studying transportation systems though he linked the complex system which consists of connected units or subsystems where relationship are poorly known, system outcome is unpredictable and enormously different from short and long term span. Moreover, small amends have the capability to produce enormous outcomes. Additionally, it opens aspect in CLIOS means that it includes social, political and economical interference. As a result CLIOS have large impacts on amplitude and extent and often long extended resided. The last important point is CLIOS performance measures or key success factors are difficult to identify and often hard to measure.

Cognitive edge group and David Snowden introduced the Cynefin Framework (Snowden and Boone, 2007) which is a decision making framework developed to recognise different domains in order to propose appropriate approaches to handle simple, complicated, complex, and chaotic scenarios in complex projects environment. Cynefin Framework is a tool aiming to understand complexity within an organisation; it is based on the social complexity-based approach by studying human experience in the past and how human predict future. The framework boundaries shape ways of dealing with domain according to data observed, this will guide the behavior to fit with context. Therefore, both the ways to interpret the world and to response in it will enhance requisite diversity to sense weak signals (Snowden and Boone, 2007).



Complexity (Cynefin)	Practices	Work Type	Skill Level	How to Achieve
Simple	Best	"Assembly Line"	Proficiency	Training
Complicated	Good	Information	Fluency	Training + Experience
Complex	Emergent	Knowledge	Literacy	Deliberate Practice
Chaos	Novel	Concept	Mastery	Deliberate Practice (10,000 hrs)

Figure 2-12 [Domains of the Cynefin model (Snowden, 2007)]

Simple: cause and effect relationships are clear, predictable, and repeatable. (Sense, categorize, respond) legitimate best practice (known), that will need Standard operating procedures

Complicated: cause and effect relationships exist yet not self-evident so will require expertise. (Sense, analyze, respond) several good practices where you cannot push one solution. (Knowable) that will need scenario planning.

Complex: cause and effect understandable in hindsight with unpredictable emergent outcomes. (Probe, Sense, respond) emergent practice or novel. (Complex Adaptive system)

Chaotic: cause and effect relationships never exist outcomes are unpredictable (Act, Sense, respond) novel practice (crisis management)

Disorder: space for not knowing about the domain we are on

One of the important principles in this framework discusses the Cliff and how the boundary between simple and chaotic is seen as a catastrophic one when complacency leads to catastrophe, if we start to believe that systems and projects are simple and will cause fall over the edge and will cause radical and extreme impacts which is called high impact events. This is indicated as wave between simple and chaotic domains "Catastrophic change" which is discussed as Black Swan theory in Taleb work.

Cynefin model helps project management realize roughly where the project among these domains in order to choose proper approach, processes, and tools that expected to work efficiently. Afterward without continuous attention to the external environment and project environment, organisation can fall from the simple domain to chaotic or even move between the four domains or even worst case slip into disorder (Snowden and Boone, 2007).

Taleb focuses on the extremely rare events known as outliers and how humans tend to simplify those events retrospectively which are now well known as Black Swan theory. He emphasizes the need to build robustness in systems rather than predict outliers (Black Swan events) in order to cope in the face of uncertainty. Since extreme events when taking place will have a great impact on our life, economy, market, and projects due to that fact they are unexpected. The main differentiator in this theory that Taleb considered was mathematical and human epistemic biases in decision making process. Since the decrease in knowledge about rare events make them invisible based on past experience (Taleb, 2007, 2008).

The complexity challenge (in project management) is essentially concerned with coping with the unintended consequences (emergence) and the difficulty of making sense of situations as a consequence of our cognitive limitations. Furthermore, in order to improve our capabilities to cope with complex systems, we have to not only predict and forecast then improve forecasting the future, also mitigating risks mainly by decoupling and last of all work in tradeoffs (Sargut and McGrath, 2011).

In a nutshell, the systems that are highly complex and closely coupled when experience failure, propagate and influence other systems in unexpected and unmanageable sequences (Perrow, 1999).

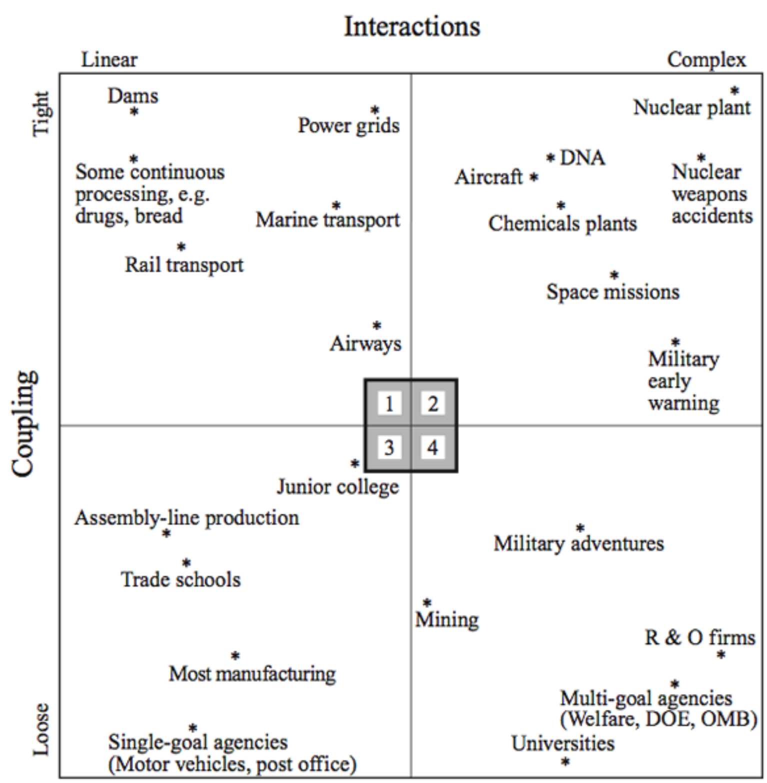


Figure 2-13 [Perrow's Interaction /Coupling Chart from his book "Normal Accidents" 1999.]

Looking to the top right zone of Perrow`s chart it become clear that certain systems or projects such as nuclear plant and space mission have the potential to form catastrophic accidents what also called black swans or wicked messes due to its complexity combined with tightly coupling scenario, which made it hard to control and manage thus could lead to disaster (Perrow, 1999). Bourne stated in here Article Averaging the Power of Portfolios that "if you are trying to determine the stability of a plank between two stepladders doubling the information from wobbling just one is not a lot of help" this implies that you cannot average or even add risks due to the tightly coupling and connecting uncertainties and risks (Bourne, 2012). Then studying the Tipping Point, which implies capability to absorb effects of change until the 'tipping point' is reached and then there is a sudden catastrophic change similar to the plastic deformation in metallurgy science, will guide the way to deal with such systems (Weaver, 2007).

In recent research Loch et al. (2011) stated that project management could reduce projects complexity by taking few steps as decoupling and modularisingprojects by leaving some features, markets, or countries to control the whole project. Next step is by freezing less important components. Finally, utilise control and fast response approach. Using design structure matrix (DSM) project management will apply systematic policy for managing complexity at portfolio and project levels:

1) Diagnose portfolio complexity by graphical representation of DSM tool with interactions across projects (Sequential, independent, or coupled.
2) Conduct business case for interactions that essentially involve business or technology.

3) Spot correction loop to reduce interaction by decoupling and modularization.
4) Communicate complexity to related teams based on DSM interactions.
5) Implement project management systems to enable teams to deal with complexity.

However managing complexity should as well engage Leadership to support processes and tools to diagnose and manage complexity continuum (Cooke-Davies et al, 2011).

2.4.4. Complex Adaptive System

As scientists continued to investigate a universal phenomenon the new Complexity Theory emerged, a theory sprouted on the interdependency, interconnectivity, emergence of patterns. A theory where systems like; weather systems, immune systems, social systems are complex and are continuously adapting to their environment to form complex adaptive systems.

A Complex Adaptive System (CAS) is a system which reveals behaviours such as learning, emergence and co-evolution like ant colonies, fish shoals and birds flock. These unified themes hopefully will develop metaphors for managing programmes and projects.

CAS predominantly shares its themes and characteristics of complex systems across most disciplines with cybernetics, natural science, and systems theory. It was originally founded and developed in Santa Fe Institute though the work of Mitchell Waldrop, Murray Gell-Mann, John Casti, and John Holland.

Holland defines Complex Adaptive System (CAS) as “a dynamic network of many agents acting in parallel, constantly acting and reacting to what the other agents are doing. The control of a CAS tends to be highly dispersed and decentralized. If there is to be any coherent behaviour in the system, it has to arise from competition and cooperation among the agents themselves. The overall behaviour of the system is the result of a huge number of decisions made every moment by many individual agents” (Waldrop, 1992).

For a better understanding of Complex adaptive systems (CAS) it is necessary to study the characteristics that make Complex systems adaptive as Emergence, Co-evolution, Self-Organizing, and Adaptive capacity which endows the system with required resilience, flexibility and agility during any phase of changes in the environment or within the system itself. Even Complex Adaptive System is similar to self-organizing systems but has the capacity to learn from experience.

2.4.5. Complex Responsive Processes of Relating

Ralph Stacey developed new ways to understand human interaction, collectively emergent and evolvement. His theory, Complex Responsive Processes of Relating (CRPR) treats projects as a set of arrangements rather than structures and command. The controls are initiated on the processes related to one another rather than managers; therefore, soft skills act as key contributors at managerial level and are needed to in achieving targeted outcomes. Furthermore, human interaction and communication becomes a base for novelty and emerging behaviour within projects and organisations. Ultimately this system has the capacity to evolve gradually, forming mixed order and chaos, stability, novelty, intentionality and paradox. This result in what is called the processes of relating (Stacey, 2001, 2012).

Complex Responsive Process of Relating requires major concerns of the following three elements:

- Processes in relating should be identified by knowing process characteristics using systematic process plan, which will also identify activities and human and system actors in the process.
- Related actors with agreement level and certainty as per Stacey's matrix.
- Open communication between actors, which sometimes could be restricted, but will never be totally closed communication within business processes.

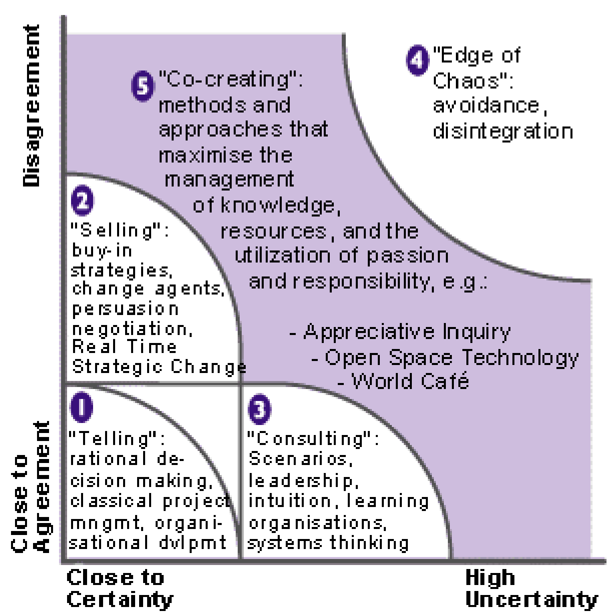


Figure 2-14 [Ralph Stacey's Agreement & Certainty Matrix (Stacey, 2001)]

In CRPR managers are required to work with different sets of competencies mainly understanding patterns of communication, and even enforce communication that enhance learning and aggregate knowledge to encourage evolving relationships. (Cooke-Davies et al, 2007)

CRPR is concerned with the unpredictability of communication effects or stimulus within the relationships that includes project team and all stakeholders. According to CRPR all projects are complex but with different degree of complexity. Eventually, CRPR persuades more attention to patterns of communication and refocuses attention from management of project complexity to management in complexity (Baet, 2006).

Stacey highlighted that complexity should not be used as a slack metaphor, as does most management literature, Complexity Theory is theoretically interesting, but difficult to apply in practice. Since the interest of complexity concepts can lead to polarization `two valued logic', i.e., value the new thinking while live and remain connected to the old school of thoughts (often distinguished as Newtonian). This will lead to a quest for more holistic methods and frameworks in order to understand and design Project management methodologies and processes.

2.5. Complexity and System Thinking

System thinking was initially coined in 1956 by MIT professor Jay Forrester; it believed that system dominate rule will develop equilibrium while complexity stress systems resist equilibrium which is exposed in controlled systems versus self-organisation. Moreover system thinking isolates elements or agents to understand system behaviour where complexity studies systems as unity.

Today's projects are linked to higher technologies that are changing regularly. They are executed in global markets that are complex, hassled with inadequately understood outcomes and overflowed with risk and uncertainty. Such projects and programmes are unpredictable as they are undefined and hyper-connected between each other and its environment.

Several attempts have been made to analyse complexity. There are two models that are generally used to understand the outlook of managing projects in complexity and may help select projects teams, distribute resources, choose tools, and evaluate risks plus uncertainties. The first one is called UCP Model (Uncertainty, Complexity, and Pace) and the second is NCTP Model (Novelty, complexity, Technology, and Pace) (Van Sommers and Williams, 2002):

- **UCP Model** (Uncertainty, Complexity, and Pace):

It is framework to identify project dimensions as Uncertainty, Complexity, and Pace, where uncertainty is divided into internal and external uncertainty and identified in levels to determine project environment. It is captured at the moment of project initiation. The second dimension is complexity and it is linked to project size, number of elements, variety, and interconnectedness. The last is the pace which indicates speed and the available time frame that limit the project.

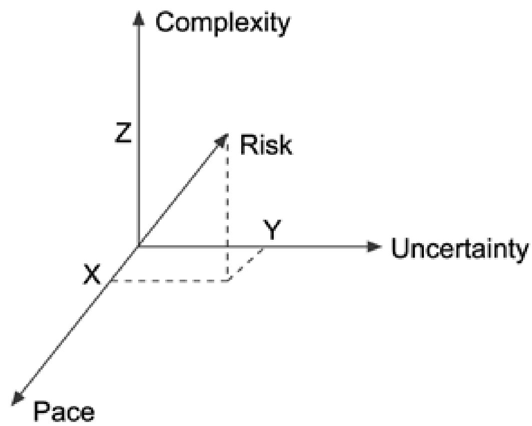


Figure 2-15 [UCP Model of Uncertainty, Complexity, and Pace (Shenhar et al., 2002)]

- **NCTP Model** (Novelty, complexity, Technology, and Pace):

It is also called the Diamond Model; it identifies risks, opportunities and gaps between the appropriate project team with management team style, the employed team and style on projects. It is valuable for selecting approaches during project planning and initiation (Shenhar and Dvir, 2007). The Model consists of four dimensions. First, is Novelty which represents the uncertainty in project goals since it identifies innovation and originality of the project outcomes. Second dimension is of Technology and the level of technology that is needed to achieve the project outcomes. Third, is Complexity level of organisation project or product and the final dimension of this model is the Pace, which represents urgency to complete the project. Each one of the four dimensions is identified on the chart below to shape up the diamond that indicate and distinguishes projects.

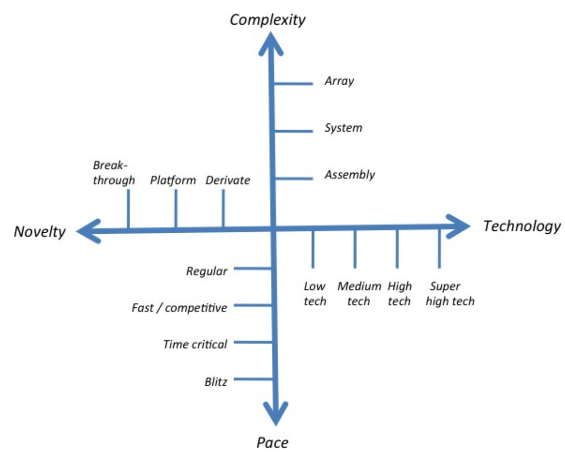


Figure 2-16 [NCTP Model of Novelty, complexity, Technology, and Pace (Shenhar et al., 2007)]

Project, Programme and Portfolio as a system will have different states to be considered. For instance, communication patterns within the project team can pose a situation where everybody is communicating with everybody else or a state where everyone communicates though the Communications Plan only (Holmdahl, 2005). Having different states or conditions explains the reason behind successful projects or organisations failure to deliver similar outputs and outcomes.

It is not surprising that project management has a low percentage of success being 35% (Standish Chaos Report, 2006).The main cause of this low percentage is that we never perform a project pre-mortem or even post-mortem considering all the states and condition of Project, Programme and Portfolio (Klein,2007).

2.5.1. Engineering Complex Systems

Most organisations add complicatedness in order to cope and manage complexity by adding more inept procedures, processes, structures and control points. The difference is not clearly recognised due to the fact that complexity is developed from the hurdles and obstacles that are faced by the organisation and these complications evolve into complex systems (Bar-Yam, 2006). Thus the entire discipline is established and captures a great interest in Systems Engineering, known as Systems-of-Systems which focuses on integration of independent operational systems along with the evolution of customer needs, system technologies and managing several different stakeholders with conflicting needs with time (Greene, 2006).

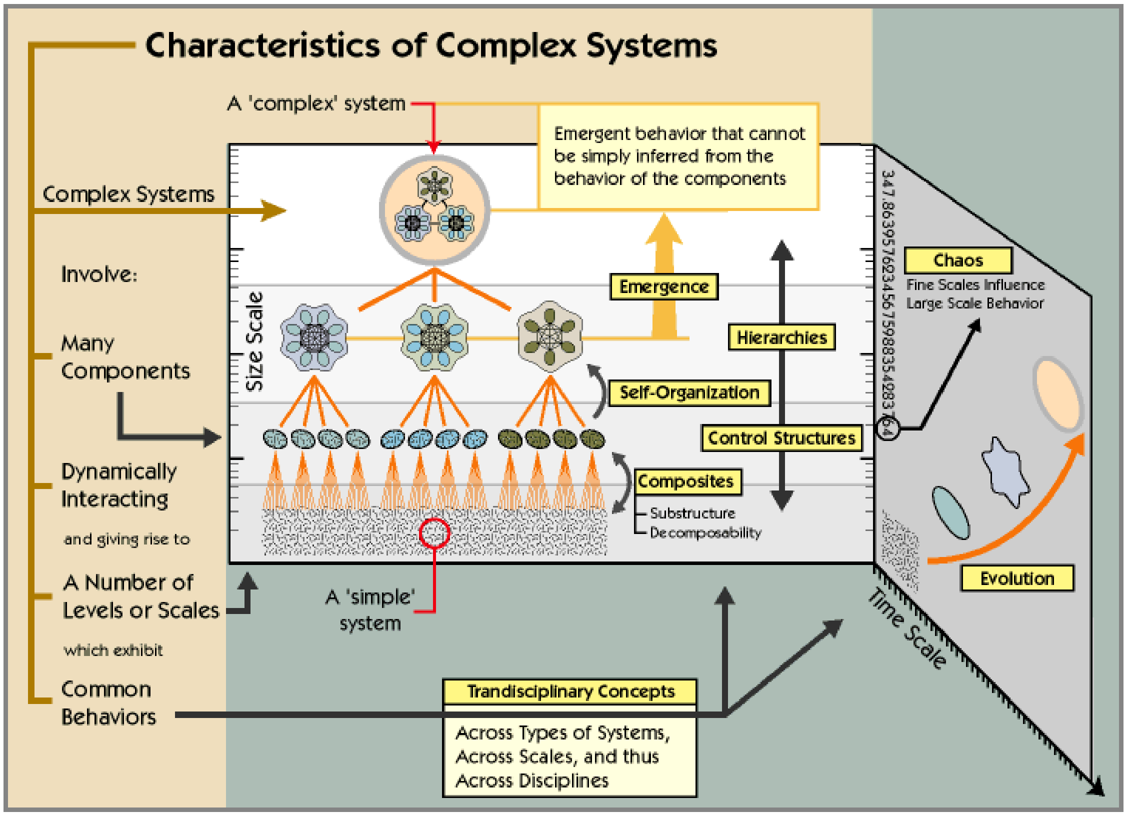


Figure 2-17 [Complex Systems Evolution (Bar-Yam 2006)]

These principles apply to the engineering of complex systems since system engineering is mainly concerned with solving the problems by planning during the design phase and then applying the solutions during the operation. This is common with complex systems engineering as it more concerned about the recognition of the complex systems and their evolutionary trends. Once the evolutionary trends are recognised they are engineered to obtain useful results. Regimen of Complex Systems Engineering listed below (Norman and Kuras 2006):

1. Give precise and conscious attention to the development environment
2. Outline development during operations

3. Identify outcome spaces, not specific outcomes
4. Create incentives or penalties for make decisions that lead complex system to enter the targeted outcome spaces
5. Evaluate results
6. Apply developmental stimulants
7. Measure continuously current conditions
8. Enforce safety regulations
9. Developmental rules of interactions
10. Duality between design and operation

A different perception on complexity reflected on the systems context. Based on this problem and possible solutions will enclose subjective and objective complexity; since social aspect is involved in the system contexts, as an element in the system or as part of the environment.

Controlled systems subjected to traditional engineering. Applying such behaviour of this system by means of a complex system might consider either truly random or chaotic natural by influence of social systems as part of the context of an engineered system. The aim of systems approach is organized complexity, and then selects structure system elements that assist to manage and respond both objective and subjective complexity (Sheard and Mostashari 2011).

2.5.2. Managing Complex Systems

Managing complexity by adopting a particular structure may not lead to the desired outcomes for an organisation actually this could limit information and creating misinterpretation of management (Stuart, 1995). Complexity theory mends the belief that parts are in isolation; it proposes that better performance can be achieved by tuning the conditions, taming the change and reducing variation. This natural origins metaphor when applied in management state that; relationships between parts are more important than the parts themselves. Furthermore, detailed complexity management principles are based on the complexity theory themes list below (Toni and Comello, 2010):

(1) Self-Organisation: This doesn't mean lack of leadership. It is new complex leadership that values the emerging from bottom to top based on collaboration with employees and integration with suppliers and customers.

(2) Creative Disorganisation: Also known as the edge of chaos to have change to be able to survive since static leads to organisation death.

(3) Sharing: sharing is a must to improve and progress toward operational excellence. It is the self-strengthening process.

(4) Strategic Flexibility: since organisation request to be agile and adaptive during the phase of uncertainty and risks. It should have strong response to weak signals while differentiate noise from signal.

(5) Network Organisation: it is the openness to external and internal inputs. This implies organisations to shift from castle to network style.

(6) Virtuous Circles: this is power connection between development and innovation

(7) Learning Organisation: this the ultimate target to have an organisation that prompt error tolerant environment and encourage learning and exploration culture.

Keeping in view these seven principles of complexity theory and applying them to an organisation's management, three laws can grant competitive advantage over competitors based on these principles.

First, is Openness since all complex systems are open to exchange of information with internal and external environments. Second, is the Dynamic equilibrium and living on the edge of chaos to encourage innovations and optimization. Third, is flexibility that enables organisations to deal and benefit from the changing environment (Toni and Comello, 2010).

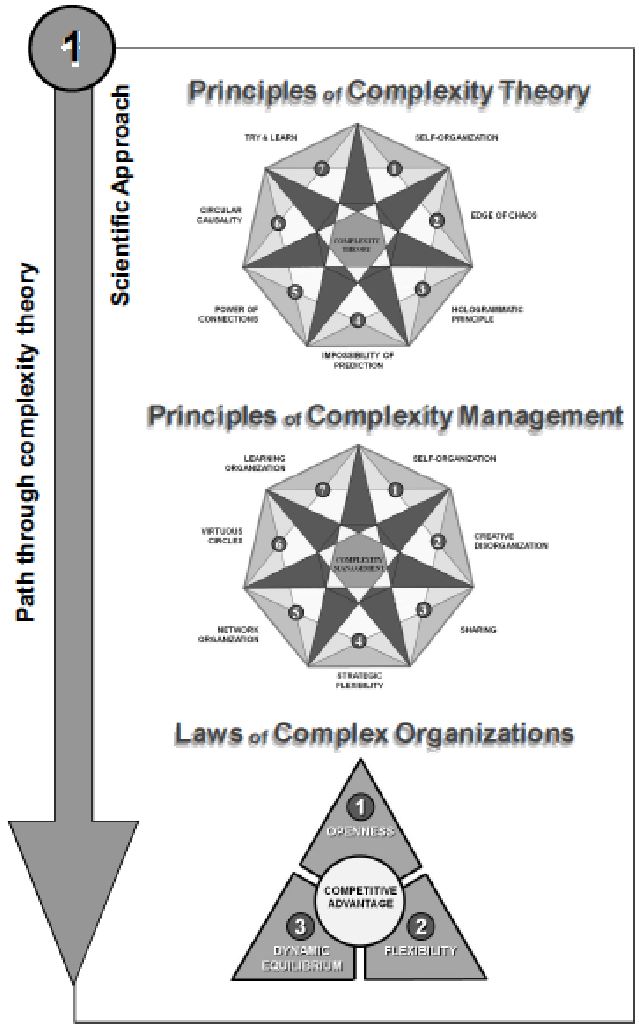


Figure 2-18 [Complexity Management principles (Toni and Comello, 2010)]

Projects can manage in complexity by looking for the factors that are easiest to change. An organisation must manage projects dynamics and uncertainties. Though flexibility and agility plus constantly have a plan B by keeping track of critical issue and warnings (Bertelsen & Koskela, 2003).

2.5.3. Modelling Complex Projects

Agent-Based Modelling (ABM) split into four areas: Complex adaptive systems (CAS), computational models, self-organizing models, and dynamical models. Those models approach complex systems in different yet overlapping approaches. Complex Adaptive System Approach creates patterns that can guide the entire system. There is no central control unit; control is within the system; since set of simple rules control the way agents interact with each other, this interaction is self-organizing because each agent have to follow the rules of interaction (Stacey, 2007).

Self-organizing modelling technique is based on emergent property of a system by which agent simply controlled by the local information and not controlled or restricted by pre-defined goals. These microscopic interactions shape macroscopic emergence. This situation will lead to higher-order, nonlinear models which cannot be modelled by linear differential equations (Cilliers, 1998).

Traditional project management models prove not to be efficient for the complex projects. New models and techniques are required to explore complex projects, furthermore new models and methods to manage them. In order to accomplish this using simulation models in congestion with Traditional project management models could be one option. Create new holistic models based on System Dynamics.

System Dynamics (SD) was developed in 1950s by Jay Forrester and since then been widely used to predict the behaviour of systems, moreover predicts the way parts of the system interact to produce system results. The modelling approach aims to understand feedbacks relationships based on causal maps. Behaviour of model form patterns which are important even more than their statistical values (Sterman, 2000).

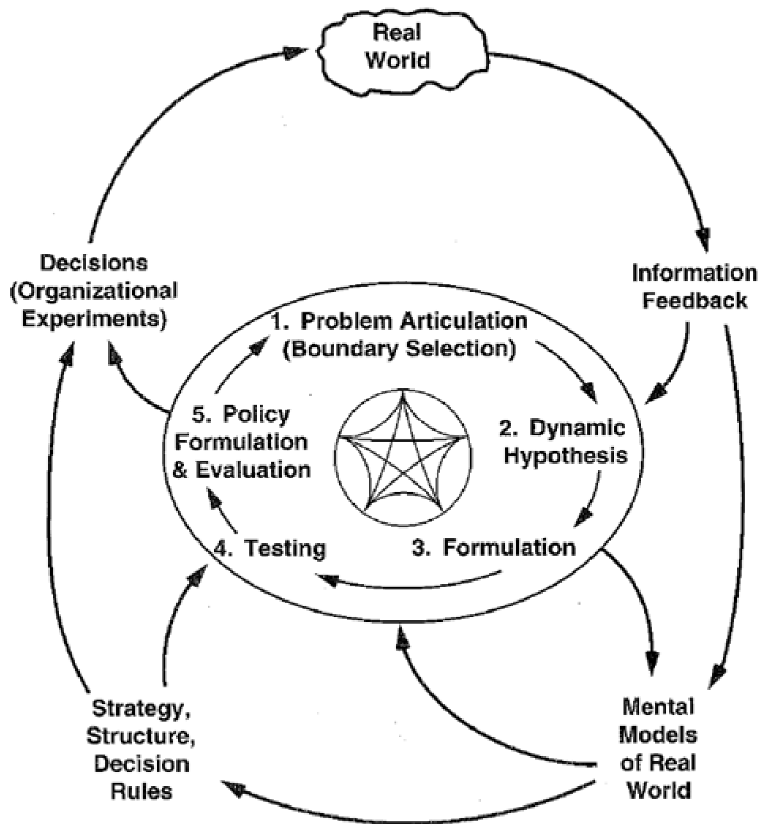


Figure 2-19 [System Dynamics modelling process (Sterman, 2000)]

In order to build system dynamics model four stages needs to fulfil:

(1) Conceptualization: where the purpose of the model, model boundaries and behaviour are defined. (2) Formulation: at this stage the feedback loops will be converted to equations. (3) Testing: testing a model by simulation besides test the

hypothesis and assumptions. (4) Implementation: this stage will run the model in different policies and environments.

Sterman (2000) simplify system dynamics modelling elements as below:

1. **Causal Loop Diagrams (CLDs):** it is a mental models show the variables of a system with the "causal" relationships and feedback loops.
2. **System Dynamics (SD) Models:** Combined CLD+S&F which describes the dynamic behaviour of a system
3. **Model boundary chart:** Endogenous/exogenous/excluded variables
4. **Sub-system diagrams:** Overall architecture of a model, comprising sub-systems and flows of things between sub-systems

System Dynamics is a simulation modelling used to evaluate the systemic behaviour of complex systems; combining System Dynamics and traditional project management result to enhance the project complexity recognition, accordingly result in to better decisions. But, this requires an effort to represent the entire project conditions and environment. System Dynamics models the project can clearly highlight risks, this leads to observe early of risk signs, which if not seen may stay undiscovered until tipping point reached. Through System Dynamics models, the dynamic nature of projects will be handled well (Li, 2008).

Different structures utilised to model projects which could be grouped in Project features: when System dynamics model features found in system such as processes, resources, and management models. Then Rework Cycle: where System dynamics set of structures that make a specific model types. Also Project Control group: that tries to model in order to improve the control through feedback loops to fill the gaps between project deliverables and actual performance. Finally the Ripple and knock on effects: Modelling "ripple effect" will force the concept of policy resistance. But "knock on" effect in project models utilizes the idea of accidental side effects to explain project behaviour and performance by creating generate secondary and tertiary feedbacks (Sterman, 2000).

Project management and system dynamics models are generally utilised to show the best forecast of current project resource including outcomes related to stakeholders. By taking into account the forecast of project resources and project environment. Thus exposed resources going to be observable in order to consider decisions that fit management strategies. Actions would be requested to change the high complex environments, where project management may experience unsuitable circumstances. Projects Complexity modelling as a tool for project management is studied by Vidal and Marle (2008), where complexity is considered as a source of risks; then those risks may impact project complexity.

2.6. Project Management Bodies of Knowledge & Complexity

During the last fifteen years the project management associations have been publishing Project management Bodies of Knowledge (known as BoKs) to provide standards, certification and best practices to practitioners and organisations. It was until 1980s when first PMI, the US based Project Management Institute embarked the first Project Management "Body of Knowledge" (BoK). The Association of Project Management (APM) BoK followed this, the UK based Association and subsequently by IPMA, AIPM and P2M, the Japan based Association.

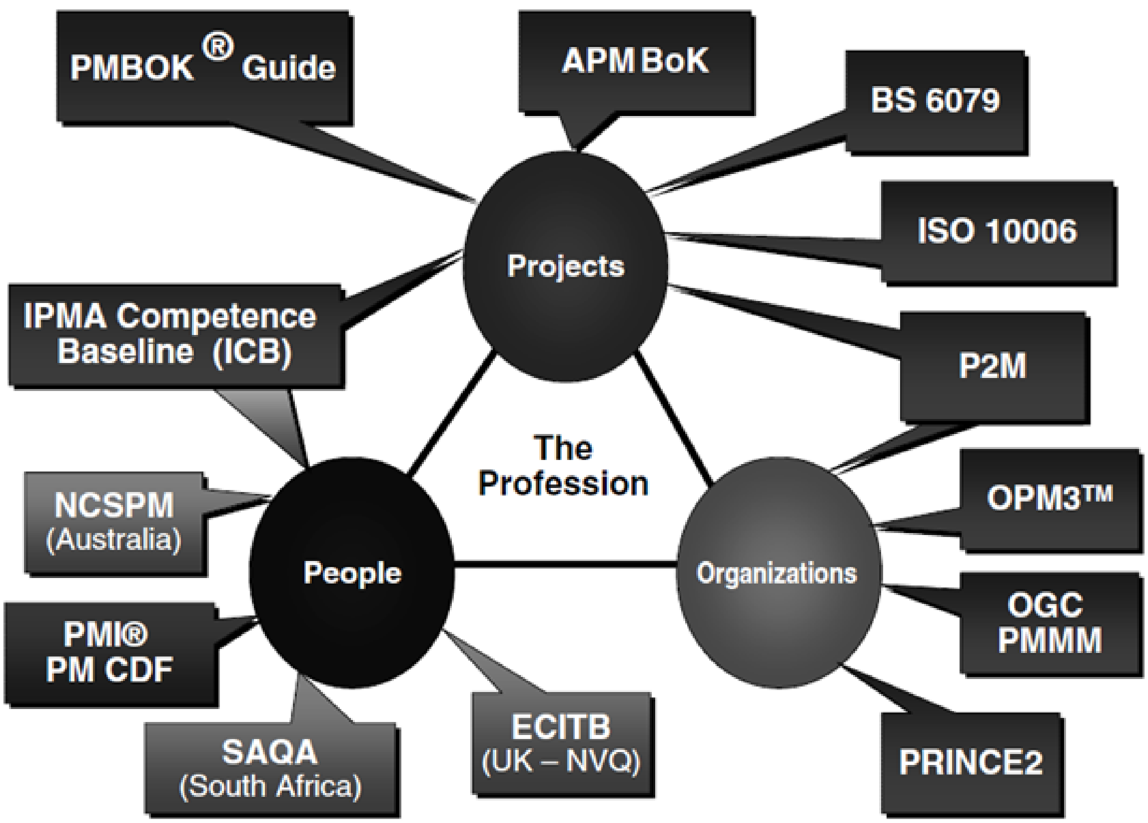


Figure 2-19 [Summary of standards that focus on Projects, People and Organisations, (Morris & Pinto, 2004)]

There are, in fact, at least three different BoK's: PMI, APM and IPMA arguably leading to some confusion across the project delivery community. The PMI BoK tends to focus on the necessary processes that are required to deliver a project that is capable of meeting the 'iron triangle' measures of time, cost and quality. On the other hand, the APM approach tends to adopt a general view of project management by addressing the project context; technological, commercial and generic management necessary to deliver successful projects (Morris, 2005).

More recently, project management bodies of knowledge, acknowledging and addressing some perceptions around lack of relevance to practice and poor coverage for major concepts such as complexity (Curlee & Gordon, 2011) have begun to update their Book's and certifications/accreditations to cover this gap.

The APM BoK realizes the importance of complexity by adopting Registered Project Professional categorization and certification for complex projects and programme s where project complexity questionnaire are designed to assist in classifying projects complexity (Morris, 1999). Complexity of projects linked to:

1. Objectives, assessment of results
2. Interested parties, integration
3. Cultural and social context
4. Degree of innovation, general conditions
5. Project structure, demand for coordination
6. Project organisation

7. Leadership, teamwork, decisions
8. Resources, including finance
9. Risks (threats and opportunities)
10. Project management methods, tools and techniques

APM BoK also has dedicated section on People that discussed human behaviour and relation regardless of the PM BoK which is silent in this regard and only concentrates more on processes and tools. PM BoK has also been criticized for concentrating on hard skills rather than the soft skills as compared to the other BoKs (Morris et al., 2006; Curlee and Gordon, 2011).

Most of BoK views are reflecting role of Organisational culture and environment. Traditional project management knowledge in books and BOKs doesn't reflect how project management is accomplished. Also, despite the fact that project management attempts to cover diversity disciplines and fields, its practice is field specific and each field or domain of work can develop unique management methods (Whitty, 2010b). As a result project managers think beyond the BoKs and even Whitty proposes the following resolutions to tackle those concerns:

i. Bottom-up approach that involves all project stakeholders.
ii. Project management methods and tools need to be tailored to fit each field-specific need.

iii. An open source approach to share academics and practitioners experience and work where each field or domain specific knowledge accumulated and evaluated.
iv. Create culture that facilitates project stakeholders to report their experience and failures without being evaluated about even being punished.

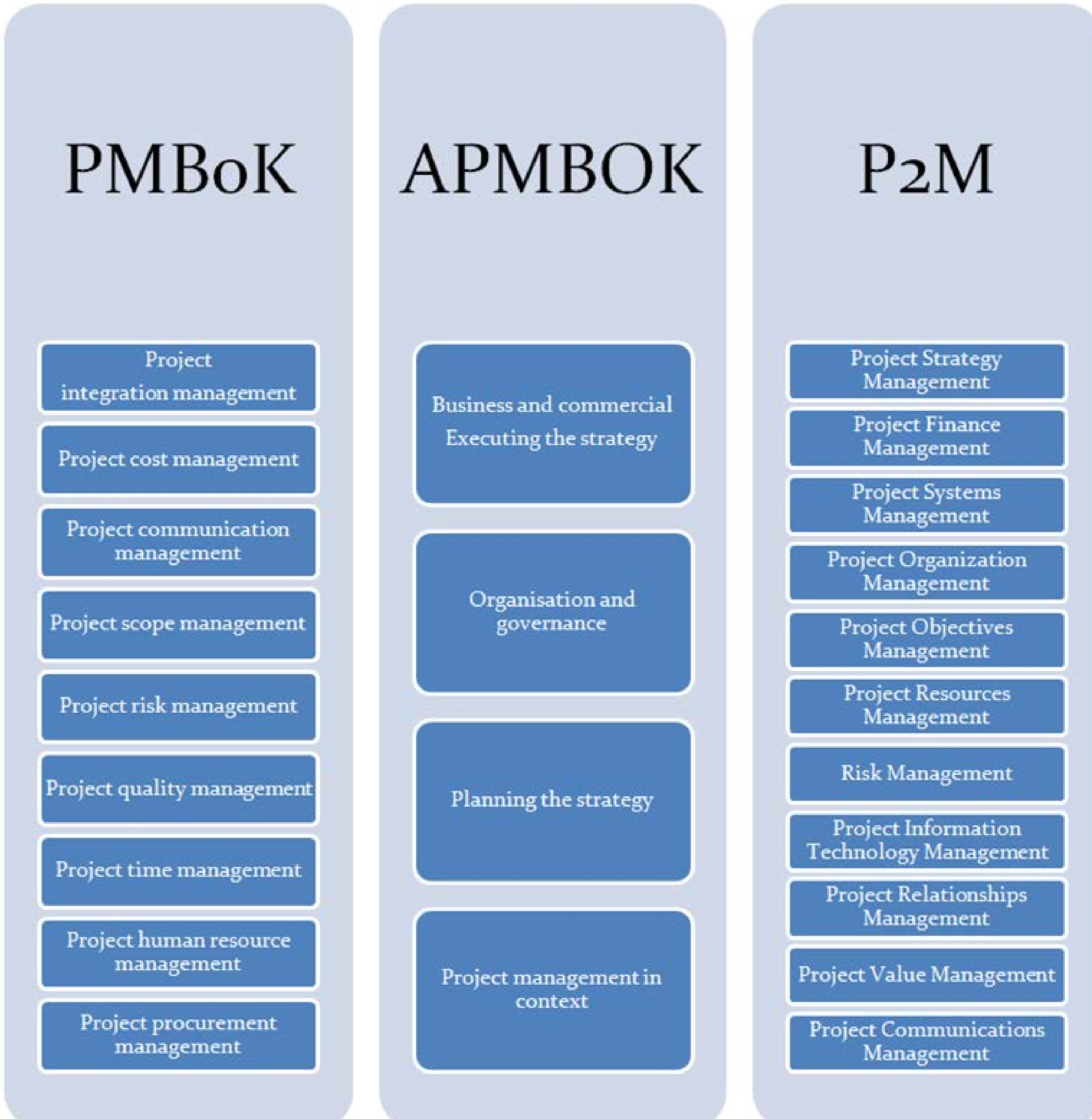


Figure 2-21 [PMBoK, APMBOK and, P2M knowledge areas]

The PMBoK is the most famous, covering nine knowledge areas shown on (Figure 2-21) where is the PMBoK cover project planning, execution and control, the APMBOK and the P2M cover that and stress on the management of projects than on project management, since it contains more aspects of management through the project life-cycle (Smyth & Morris, 2007).

In APMBOK and P2M, there are clear attentions for more strategic aspects that may reflect in complexity feature. Yet PMBoK strongly focus on internal processes and barely focus on project design and processes. While the IPMA focus is oriented to technical, behavioural and contextual competence aspects of project management. The IPMA classification includes Organisational and technical aspects (Rekveldt et al., 2011).

Terry Cooke-Davies (2011) coined a new direction for next generation of practices fit for the complex projects management as Project Management 2.0; however, it was clearly mentioned that standard project, programme, portfolio practices and tools should be incorporated and extended to exploit complexity along with encouraging innovation in order to permit agility and flexibility. This is achieved by three hierarchies: organisation level, governance level and project level. However, these recommendations involved in three levels have specific practices and processes that cover four areas: policy, structure, people and processes (Cooke-Davies et al, 2011).

At Organisational level where executives set up polices that cover the whole organisation, the PM2.0 recommend

1. Drive portfolio selection and evaluation through a value creation aspect.
2. Embrace complexity that adds value while avoiding making activities more complex than necessary.

3. Follow the portfolio capabilities in terms of resource and complexity.
4. Focus attention on workforce development in the complexity.
5. Develop standards to permit different methods for different projects.
6. Adopt structures that persuade systems engineering and project management cooperation and collaboration especially in the early stages of programme and project life.

Besides that at governance level:

1. Establish governance structures to minimize "optimism" bias and political power-plays.
2. Integrate governance structures with the project structures.
3. Ensure governance in order to cope up with complexity of projects and programmes, at the same time as utilise tools to reduce dysfunctional complexity.
4. Understand the dynamic linkages to prevent systemic risks.
5. Ensure teams are competent enough and motivated to govern.

Finally at the programme or project level:

1. Adopt integration centric development (ICD) so that the project team implement the "whole project approach"
2. Stress on the leadership with management.
3. Develop methods and tools to cope with complexity, deal with emergency and encourage innovation.

4. Ensure teams have common understanding of systemicity in the project to incur that in planning and risk management.
5. Facilitate communication of project team with the whole organisation.

This study by Terry Cooke-Davies, Lynn Crawford, John R. Patton, Chris Stevens, Terry Williams expect complexity only to rise so we have develop ability to manage it, and join the standouts by turning complexity into financial and competitive advantage. This effect summarized on the table 2-7 showing list of recommended (Cooke-Davies et al, 2011).

Table 2-7 [practices recommended in Project Management 2.0 (Cooke-Davies et al, 2011)]

	Organisation	Governance	Project
Policy	1. Appropriate Organisational attention to programme and project management 2. View not only individual programmes and projects but also the disciplines of project management and systems engineering from a value-creation perspective. 3. Establish a framework that relates complexity to business strategy. a. Allow the use of practices that are appropriate to complexity. b. Establish a common language of complexity throughout the organisation. c. Assess Organisational capacity to manage its complex programmes and projects.	1. Establish estimating policy after making due allowance for complexity and for technology maturity	
Structure	4. Structure the organisation to classify "tasks" in a way that is complementary to the structure of business operations and covers all portfolios, programmes, and projects. 5. Make smart use of PMOs. 6. Ensure that the structures encourage the integration of systems engineering (or its cousin, business analysis) with project management. 7. Institute structures to support me development of a project-capable work force. 8. Create discipline-based communities of practice.	2. Establish governance structures for programmes, projects, and programme and project management that minimize optimism bias in estimates and forecasts. a. Ensure appropriate balance of authority between the line and project management. b. Ensure that the project structure and the governance structure are integrated.	1. Structure projects around integration for better understanding of system anatomy. 2. Adopt flexible semi-structures linked to time constraints. 3. Plug project team networks into organisation communities of practice.
People	9. Align the views of Organisational programme aria project success among all Organisational stakeholders 10. Recruit and develop programme and project managers with strong leadership skills. 11. Ensure that at people involved in managing programme s and projects are involved in a strong work force development programme. a. Progress through a career ladder personal development framework. b. Experiential learning in the workplace nee- grated with	3. Ensure that people in governance have a clear Picture of the complexity of each programme or project they are governing. 4. Understand the dynamic linkages Inherent in the project to assess the likely impact of both risks and corrective actions.	4. Pay close attention to the appointment of all key positions in programme s and projects, for example: a. Emphasize leadership as well as management. b. Look for exceptional leadership skills on complex projects. c. Appoint both project managers and systems engineers to cope with 'emergence" d. Distinguish between "civil pilots- and –fighter pilots"

	developmental activities. c. Personal aptitude for managing different kinds of programmes and projects distinguished.		e. Ensure that leaders have high emotional intelligence (EQ). 5. Develop a shared understanding within the team of the "systemicity" in the project. a. incorporate an understanding of "systemicity" into project planning b. Understand the systemic impact of combinations of risks.
Process	12. Ensure that loudness SyStenıs de not become Obstacles to programme and protect success. a. Portfolio, Programme, and project systems are integrated among themselves and with tenor business systems. b. Avoid numerous pitfalls implicit in the unthinking application of classical management Practices. c. Consider whether standards help or hinder tor different typeset tasks 13. Widen project selection criteria to improve portfolio selection 14. Categorize Projects according to their degree of complexity a. Amend management information Systems to reflect the nature or complex project b. Develop sophisticated definition methods for containing complexity c. Adapt different project methodologies for different types of projects d. Match the capabilities of individual project managers to the complexity of the programmes or project	1. Design the programme or project to optimize delivery and to reduce unnecessary complexity. 2. Employ appropriate tools: a. To map the complexity in programme or project. b. To select the appropriate estimating process for the particular project and stage. c. To apply earned value management appropriately. d. Use judgment to know when to freeze design and when to remain adaptable. e. If appropriate, use system dynamics in post implementation reviews.	6. Decide on the appropriate tools to manage complexity in the programme or project. 4. On complex projects. use "control and fast response" approaches. 5. Take small steps and control variability.

2.7. Project performance and project success factors

Late 1980s Morris and Hough coined three dimensions of project success according to different perspectives: (1) Project functionality: what level does the project perform in financial and technical aspect. (2) Project management: if project is accomplished to the agreed budget, schedule and specification. (3) Contractor's commercial performance: if the contractors achieve the expected commercial earnings.

Recently, Shenhar et al. (2001) expanded Morris and Hough dimensions into four project success:

(1) Project efficiency in time and budget

(2) Impact on customer by meeting requirements and satisfaction

(3) Business success on the organisation scale

(4) Preparing for the future: Organisational and technological infrastructure.

Following to the success dimensions, Success measures distinguished are shown in Table 2.8 (Shenhar et al., 2001).

Table 2-8 [Success measures (Shenhar et al., 2001)]

Success dimensions	Success measures
Project efficiency	Meeting schedule goal Meeting budget goal
Impact on the customer	Meeting functional performance Meeting technical specifications Fulfilling customer needs Solving a customer's problem The customer is using the product Customer satisfaction
Business and direct success	Commercial success Creating a large market share
Preparing for the future	Creating a new market Creating a new product line Developing a new technology

Different literature list various project critical success factors that enable the project success; Table 2.9 evaluate common factors related to project mission, project planning and control, top management support, and customer involvement. This will represent universal factors for project success regardless of the project context. In addition to that research of Bakker et al. (2010) was conducted within the process type of projects in which safety plays central role, this would be highly similar to oil and gas projects where Health, Safety, and Environment (HSE) one of the critical success factor.

Table 2-9 [literature comparison based on Critical success factors]

Bakker et al., 2010	Westerveld, 2006	Tukel and Rom, 1995	Morris & Hough, 1987
▪ Risk management ▪ SHE compliance ▪ Trust ▪ Cost management ▪ Value focused ▪ Team composition	▪ Project results ▪ Appreciation client ▪ Appreciation project personnel ▪ Appreciation users ▪ Appreciation contracting partners ▪ Appreciation stakeholders	▪ Client involvement ▪ Preliminary estimates ▪ Resources availability ▪ Project team ▪ Organisation ▪ Projects manager performance ▪ External environment	▪ Project definition ▪ Technical innovation ▪ Uncertainty ▪ Community involvement ▪ External factors ▪ Finance ▪ Schedule ▪ Organisation and contract strategy ▪ Communication and controls ▪ Human qualities ▪ Resource management

Dvir et al. (2003, 2006) investigate the relationship between project planning efforts and project success, and highlight a positive correlation between project success and achievement in the planning phase, again based on the 110 defence projects. Then after study project success connections to project managers' personality, and project type. And coin the NCTP framework (novelty, complexity, technology, and pace) that was discussed in section 2.4 in chapter 2.

Key Performance Indicators (KPIs) also been used to determine the performance of projects and organisations in two aspects objectively and subjectively. With KPIs are mostly estimated by two methods. The first one is by mathematical formulas to quantitatively measure based on certain criteria for each KPI (time, cost, value, safety…etc.). The second method is subjectively based on personal opinions of quality and functionality such as client satisfaction and so on (Chan and Chan, 2004). Yet the basic comment on KPIs method it's helpful in operational levels of the project and not focused in the strategic level.

Westerveld et al. (2003, 2006) models the Project Excellence which is divided to project success factors and Organisational critical success factors the model is based on the EFQM (European Foundation of Quality Management) model. Five different project types are used in order to describe the project. The project goals and the external factors of the project must fit, for the success of the choices which have been made on the Organisational areas. According to Westerveld the focus should be on project success criteria (Result areas) and Organisational critical success factors. The model illustrate that the of project success criteria being the triple objective of time, cost and quality. This will be accomplished by the critical factors of project management which cover scheduling, budget, organisation, information, risk and quality. The model demonstrate both the broad and narrow concept of success criteria could be accomplished if the critical success factors which also include policy and strategy, leadership and team, resources, stakeholder management, and contracting.

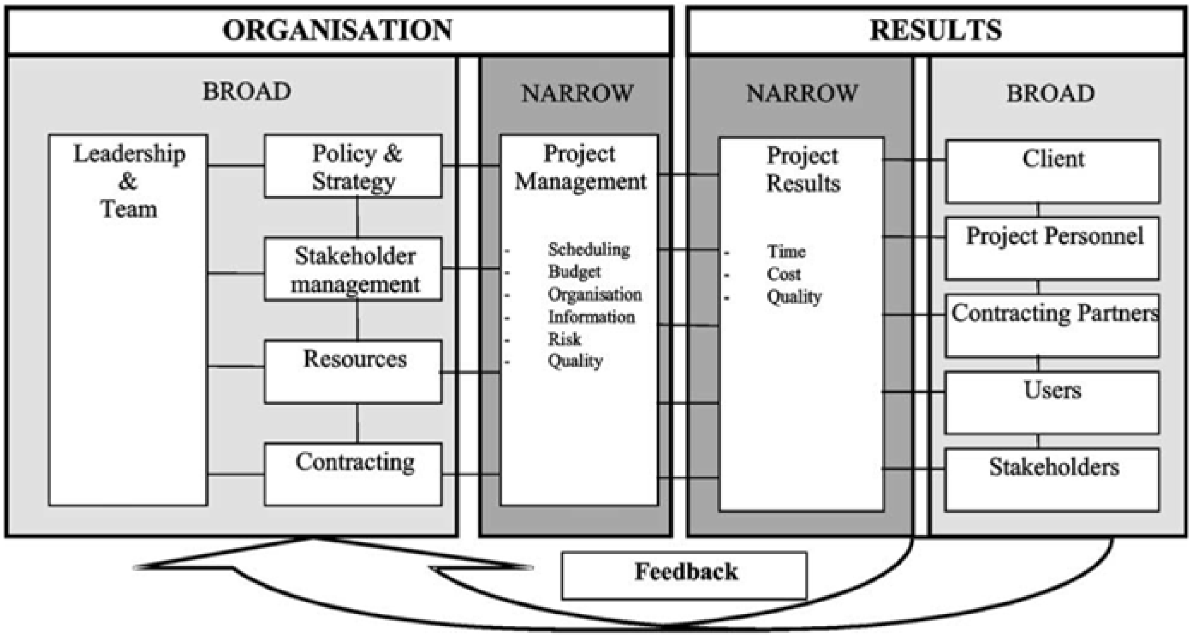


Figure 2-22 [The Project Excellence Model (Westerveld, 2003)]

2.8. Summary

By nature projects are complex also increasing technology and operating in the wider geographical world, further compound the complexity of managing projects and programmes. Furthermore, our understanding of the world is based on our mental models which are commonly implicit rather than explicit and its diversity mainly causes more complexity to complex project. That will create a necessity for processes and frameworks that employ different practices to ensure project and programme success (Cooke-Davies et al., 2011).

Complexity Theory offers a new prospective of Organisational policies and gives us as a solid base for understanding the dynamics of projects in order to deliver quality outcomes by optimising resources at the same time. A study of complexity in projects requires a wide range of data to cover the outcomes and have a deeper insight of the project details with statistically significant volume. Once the concepts of complexity and emergent behaviour are accepted by the Project Management community and teams, they can work on the edge of chaos where nonlinearity and emergence can be utilised properly to benefit the project outcomes (Ziadat, 2016).

In order to deal with complexity in projects, it's vital to set grounds for establishing the initial state of order by using negative feedbacks (control) and positive feedback (change). However, the edge of chaos, where sufficient innovation and stability can keep the entire systems from falling into turmoil and disorder, can be reached by incorporating an efficient change. Hence, complex projects can prosper successfully by developing a plan through forecasting the budget and resources, adapting and integrating a proper system, maintaining a suitable channel of communication and keeping in view the uncertainty. Eventually, the probability of success can be increased with resilience and flexibility that help in handling risks and uncertainty regarding the project and programmes (levy, 2012).

Complexity theory recognises the fact that organisations know how to plan in short term and they should utilise different approach for longer term plans that tolerate proper responses to emergence. This is achievable when Complexity is allowed to develop since it's the way to create new forms of order. Also order could be source of chaos yet if this Cliff or Black Swan happened will shroud in radical and extreme impacts (Snowden, 2007; Taleb, 2007).

Most organisations add complicatedness in order to cope and manage complexity by adding more inept procedures, processes, structures and control points. The difference is not clearly recognised due to the fact that complexity is developed from the hurdles and obstacles that are faced by the organisation and these complications evolve into complex systems (Bar-Yam, 2006). Thus the entire discipline is established and captures a great interest in Systems Engineering, known as Systems-of-Systems which focuses on the integration of independent operational systems along with the evolution of customer needs, system technologies and managing several different stakeholders with conflicting needs with time (Greene, 2006).

These principles apply to the engineering of complex systems since system engineering is mainly concerned with solving the problems by planning during the design phase and then applying the solutions during the operation. This is common with complex systems engineering as it is more concerned about the recognition of the complex systems and their evolutionary trends. Once the evolutionary trends are recognised they are engineered to obtain useful results. Projects can be managed in complexity by looking for the factors that are easiest to change. An organisation must manage projects dynamics and uncertainties. Though flexibility and agility plus constantly have a plan B by keeping track of critical issue and warnings (Bertelsen & Koskela, 2003). Managing project in complexity by adopting a particular structure may not lead to the desired outcomes for an organisation actually this could limit information and creating misinterpretation of management (Stuart, 1995). Complexity theory mends the belief that parts are in isolation; it proposes that better performance can be achieved by tuning the conditions, taming the change and reducing variation. This natural origins metaphor when applied in management state that; relationships between parts are more important than the parts themselves. Furthermore, detailed complexity management principles are based on the complexity theory themes list on Toni and Comello model for managing complexity (Toni and Comello, 2010).

3. Research Design and Methodology

3.1. Introduction

This chapter covers an outline of the structured model used to design this research. The discussions are organized around research philosophy, strategy, design, sampling size, data collection and data analysis. Furthermore, research methods are also discussed; that covers used techniques to model the research objectives.

Complexity Theory is a set of certain concepts and principles emerged through a theoretical framework that assists in handling complex systems. In the recent years, increasing attention has been given to facilitate academics, practitioners define critical success factors, and limitations in order to enable them develop certain policies and strategies that would aid the success of projects. However, the entire work in this regard has only scratched the surface and barely produced a structured discipline for project management settings in the real world (Cooke-Davies et al, 2011).

Generally, deductive reasoning is associated with the hard paradigm of project management and inductive reasoning with the soft paradigm of project management (Pollack, 2007). Therefore, in this research, a deductive approach will be utilised to enhance learning and participation and detailed information will be obtained from participants in the form of case studies, learning and experience. In the first phase, questionnaires will be developed according to our research objective and distributed among the chosen sample. The sample selected for research consists of engineering societies working in project management environment and data collection will be based on snowball sampling.

In the next phase, researcher will conduct a detailed interview of people with a solid understanding of executing projects in complexity and a clear view of various factors that contribute towards project complexity and how this could affect project performance.

Furthermore, Meta-analysis, a statistical technique combines and contrasts the findings of independent studies in the project complexity field. It intends to cover all the related and independent studies, look for the presence of heterogeneity, identify patterns and aims to achieve robust conclusions by using sensitivity analysis. Quality effects models can facilitate the outcome by giving weight to higher quality research completed in the Projects complexity (Cooper et al., 2009).

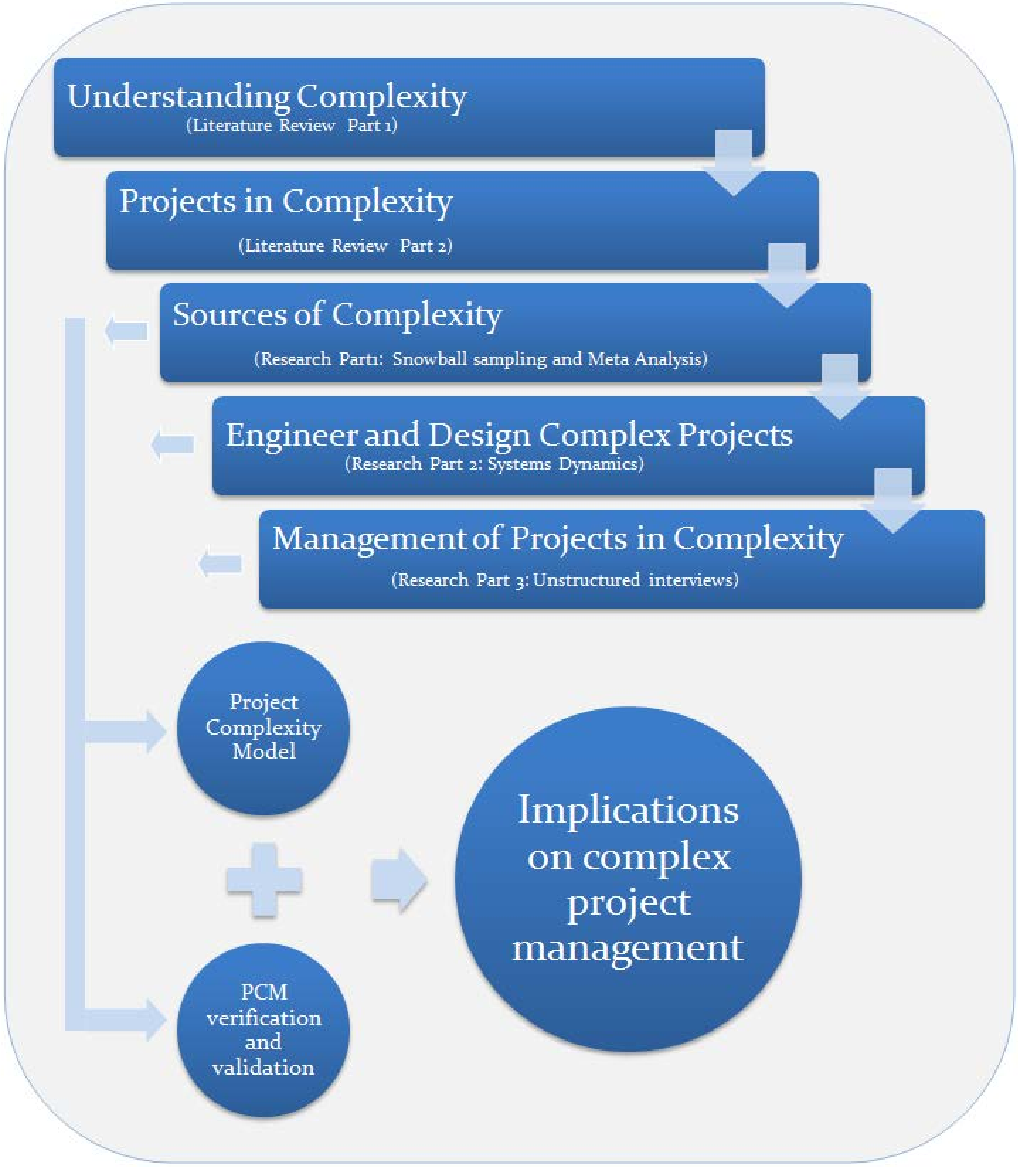


Figure 3-1 [Research Design and Model]

3.2. Research Design Framework and Model

The primary objective is to develop a complete model linking the factors connect projects complexity with project performance and success criteria by the integration process and will talk about it in detail during the factors chosen by the researcher according to the model in Figure 3-5 based on the Taxonomy of theoretical factors to in Table 2-6.

3.2.1. Introduction

The main focus of this research is the theoretical framework that led to design a research method. It also supported to illustrate the research characteristics for this study and in this way; we guarantee the reliability and validity of the results. The first phase involves the development of a questionnaire and structured interviews. While in the second phase, Meta-analysis will be utilised to statistical combine and compare the findings of previous studies in the project complexity field. It intends to cover all the studies that are related and independent of this phase, to identify patterns by using sensitivity analysis. Moreover, it also facilitates the outcomes of this model by giving a higher weight to higher quality research done in the Projects complexity (Cooper et al., 2009).

3.2.2. Research Aim and Objectives

The aim of this research is to investigate the academics and practitioners point of view regarding complex projects besides complexity in project management discipline and its contributing factors. The entire purpose is to enhance the understanding of complexity in projects and to compare the perceptions of the academics and practitioners, which demanded in-depth knowledge of complex and dynamic project setting. Afterward, compare the precision of managing projects in complexity in the oil and gas industry with the results from the meta-analysis study.

The argument mentioned above will be highly concerned in selecting an appropriate research methodology and methods to understand complexity, how it builds up in projects and programmes and gradually extends into projects Portfolio.

The research objectives centred on the points below:

i. To investigate and categorize project complexity concepts and factors in the academia, Project Management Bodies of Knowledge and the real world of project management.
ii. To recognise the effects and consequences of complexity on project processes and life cycle and how it influence project performance.
iii. To identify the ways of coping with complexity in a project without jeopardizing project outcomes and outputs.
iv. To figure out ways to engineer or design complexity in projects portfolios to govern project complexity and maximize the benefits.
v. Develop a model to identify Project, Programme and Portfolio's complexity during the entire project lifecycle.

3.2.3. Statement of the research problem

In order to fulfil the research objective the following problem statements have to be accomplished:

i. What are the benefits and limitations of quantifying project complexity from a practitioner's point of view?

ii. How can project complexity be categorized into complex engineering projects?

iii. What factors and measures contribute towards Project, Programme , and Portfolio complexity and how do they influence a project's outcome and performance.

iv. What are the procedures and controls for managing project complexity?

v. How can complexity theory be utilised to improve the performance of complex projects?

vi. How can the concepts of complexity and emergence reproduce the project management framework?

3.2.4. Research Framework and Strategy

Saunder (2009) stated that the research hardly ever falls in one philosophical domain and management research, in particular, is frequently combined with positivist and phenomenological techniques. The combination of techniques is, therefore, helpful in this work and phenomenological technique turns to be the best and robust for this research since the study investigates project complexity understanding in project actuality, which is considered in the phenomenological area. Yet, a lack of objectivity within phenomenological technique that requires moving toward a positive, quantitative approach (Saunders et al., 2009).

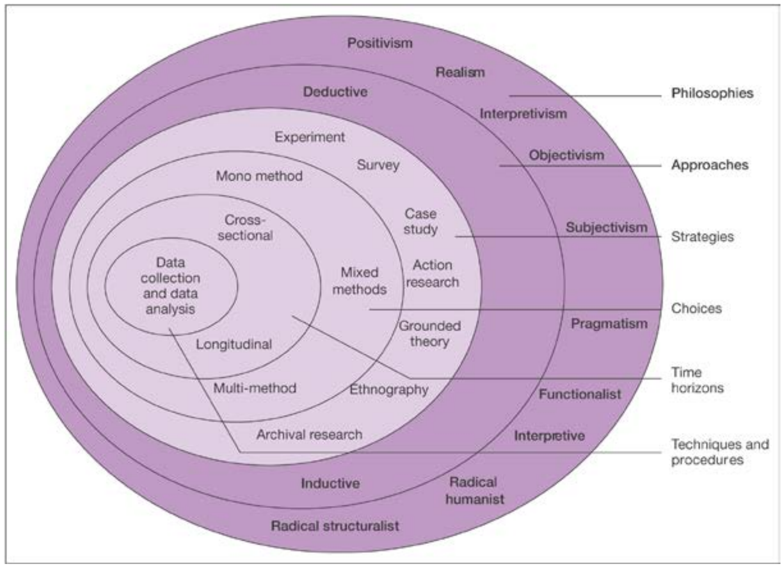


Figure 3-2 [The Research 'Onion' (Saunders et al, 2009)]

Saunders et al. (2009) divided research philosophy into positivism, Interpretivism and realism. Where, positivism is a well-structured methodology that facilitates replication to come up with common conclusions. This is achieved by logical reasoning before precision and objectivity replace hunches; it is based on a reality that is independent of the research. In this research type existing theory is utilised to build up the hypothesis to be tested and then to be approved or disproved in order to add more development of theory. The main point against positivism is the social research that studies the actions and behaviour developed within the human mind. In Phenomenology, the result of how people interpret the world is considered vital to study the meaning of human behaviour and actions.

Interpretivism challenges through subjective interpretation and intervention in reality. Interpretive philosophy carries along with it the acknowledgment that will also affect the phenomena under study. This could be a description of reality, but sustainability is part of the knowledge they are pursuing. Interpretivism requires researchers to recognise the differences between humans, which emphasise the difference between conducting research amongst human society rather than objects. In addition to understanding social roles of others, researchers set of meanings will also influence the reach context (Saunders et al., 2009).

Realism is another epistemology that shares scientific inquiry. The senses show us the reality; therefore, reality is independent of the mind, which makes it similar to positivism in sharing the scientific approach to developing knowledge. This drives the methods of data collection, then data understanding and analysis (Saunders et al., 2009).

Ontology is concerned with nature of reality by asking questions about the assumptions on the way the world operating. Ontology has two aspects:

(1) Objectivism: where social entities exist in reality external to social actors.
(2) Subjectivism: where social phenomena created as a consequence of social actors' actions concerned with their existence.

On the other side, epistemology is concerned with studying the nature of knowledge, and in what manners factors constitute acceptable knowledge in a field of study. While Axiology studies judgments about the research value transparently and recognising it as a part of the research process, this minimise bias by defending responses and recommended personal values (Saunders et al., 2009).

Saunders et al. (2009) state two research approaches: induction and deduction. An induction approach starts from data collection and the results obtained are used to formulate the theory. Where, deduction approach build-up hypothesis for new theories based on existing theory.

Deduction approach involves the development of a theory based on the rigorous test. It is central research approach in natural sciences. Whereas expectations of phenomena predict its occurrence, thus consent controlling it. An alternative approach is making cause and effect link between particular variables without paying attention to the way humans interpreted the social world. Inductive way let theory follow data rather than vice versa as with deduction (Saunders et al., 2009). This research will follow a deductive approach since many studies have been done within the project complexity. These research findings were so helpful to this research for developing more understating. However, this research will result in concepts that are more robust and result in a model to clarify the influences of complexity on project management processes.

Deduction emphasises	Induction emphasises
• scientific principles • moving from theory to data • the need to explain causal relationships between variables • the collection of quantitative data • the application of controls to ensure validity of data • the operationalisation of concepts to ensure clarity of definition • a highly structured approach • researcher independence of what is being researched • the necessity to select samples of sufficient size in order to generalise conclusions	• gaining an understanding of the meanings humans attach to events • a close understanding of the research context • the collection of qualitative data • a more flexible structure to permit changes of research emphasis as the research progresses • a realisation that the researcher is part of the research process • less concern with the need to generalise

Figure 3-3 [Major differences between deductive and inductive approaches (Saunders et al., 2009)]

Another dimension of research approach is qualitative versus quantitative, where the quantitative approach is utilised for the testing theory by analysing the relationship between variables. These variables will be measured in order to collect numbered data that will be examined using statistical methods.

Furthermore, a qualitative approach is utilised to understand individual's perception to a certain problem where data is collected in the participant's setting and the data is analysed based on the researcher interpretation. The quantitative approach is based on deductive reasoning or deduction and it utilises quantitative analysis techniques such as establishing statistical relationships between variables through statistical modelling. In comparison to quantitative research, qualitative research uses inductive reasoning though acquiring in-depth understanding of human behaviour. Therefore, it uses different data collection and analyses techniques as compared to quantitative research (Saunders et al., 2009).

Table 3-1 [Qualitative and Quantitative list of differences (Saunders et al., 2009)]

	Qualitative	**Quantitative**
Role of theory in the research	Inductive generation of theory	Deductive testing of theory
Epistemological Orientation	Interpretivism, Phenomenological	Natural Science, Positivism
Ontological Orientation	Constructivism	Objectivism

Prior to select the best approach for answering research problems between both quantitative method and qualitative methods it is important to study the advantages and disadvantages of each approach first. Qualitative approach collects the data that is not in a numerical form, which makes it subjective and allows studying the non-tangible research subjects. It is utilised to discover human experience or behaviour, to investigate and explain a social phenomenon, which is not clearly known. Qualitative data is collected by questionnaires, surveys, interviews, and focus groups, which adopt a person-cantered perspective. It explains an understanding of societal understandings and experiences (Yin, 2003).

As complexity research in project management, seek to understand the human and social context within the complex project environments. In view of that, Judgmental sampling was adopted in this research combined with snowballing sampling technique. Initially, research scope will be limited to cover oil and gas (O&G) engineering project society in the Middle East and North Africa (MENA). In order to investigate Complexity in Project management pure quantitative or qualitative approach may limit the route of problem-solving statements. Even though most of the researches on this field tackle the research with a qualitative approach, combined qualitative and quantitative approach were selected to merge the benefits of both methods, consequently answer the research questions. Generally, deductive reasoning is associated with the hard paradigm of project management and inductive reasoning with the soft paradigm of project management (Pollack, 2007).

Therefore, in this research deductive approach will be utilised to enhance learning and participation. Detailed information will be obtained from participants based on their experience in complexity within project management during unstructured interviews. In the first phase questionnaires, tackling the research objectives for being formulated and then distributed on selected samples from engineering societies working in Project Management environments associated with both closed questions. The next phase encloses structured interviews that utilise questions based on a predetermined and standardised sets of those showed a solid understanding of executing the project in complexity and have a clear view of factors contributing to project complexity (Saunders et al., 2009).

Furthermore, Meta-analysis will be conducted to aim for common views across project management academics and researchers. Meta-analysis is defined as "the analysis of analysis…the statistical analysis of a large collection of analysis results from individual studies for the purpose of integrating findings" (Glass 1976). The analysis starts with a collection of large number research results and reports, then code the findings analyse the data, look for heterogeneity, and identify patterns using sensitivity analysis. This made Meta-analysis powerful statistical tool to integrate research findings. In order to represent the quantitative findings of a group of research calculate factor known as the Effect Size (ES_{sm}).

$$ES_{sm} = \frac{\bar{X}_{G1} - \bar{X}_{G2}}{S_{pool}}$$

Where $\bar{X}_{G1}$ is mean of experiment group, is the mean of the control group and Spool is the pooled standard deviation of the two groups. The effect size provides information about how much change is evident across the studies. There are different types of effect size the two main types are standardized mean difference or correlation, and it's reported with a number of used studies plus confidence intervals to verify the consistency and reliability of the mean estimated effect size. Quality effects model can facilitate the outcome by giving extra weight to higher quality research completed in the Projects complexity (Cooper et al., 2009).

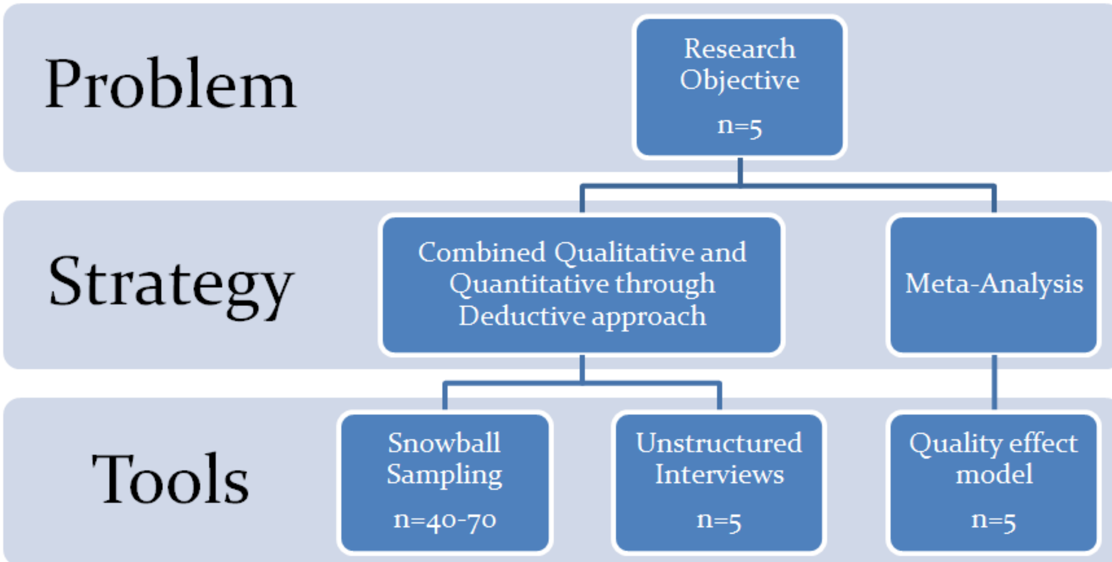


Figure 3-4 [Overview of research model maturity]

Most project management research methodologies are positivism or empiricism base. Yet positivism and empiricism considered as a linear thinking that suitable for closed cause-effect models, and not suitable to address context. Therefore, it's recommended to utilise critical realism to position research in the context of both theory and practice (Smyth & Morris, 2007).

Lately, research into project management was categorized in seven schools:

1) **Optimization School** that utilise optimization techniques and systems analysis),
2) **Factor School** research uses descriptive statistics on the factors that affect project success and failure)
3) **Contingency School** that utilise case study and survey research

4) **Behaviour School** which is interpreting Organisational behaviour and processes in projects
5) **Governance School** prescriptive research on governance and contract management
6) **Relationship School** uses case-study to relate between actors in projects
7) **Decision School** interpretative research on politics and decision-making in projects)". (Söderlund, 2011).

This research embraces the outlines of several of the schools as differentiator above the single factor school. Accordingly, contingency behaviour and the decisions school will be adopted.

3.2.5. Complexity theory implications on research model

In the previous chapter clear understanding about the concepts of complexity science such as sensitivity to initial conditions, feedback, and emergence have been achieved. MacIntosh and MacLean (1999) stated that complexity theory supposed to decide the suitable research methodology. Since complexity theory states that order emerges through the self-organisation of systems. Organisations are considered as complex adaptive systems in which the whole is greater than the sum of parts.

Moreover, complexity theory believes on initial conditions sensitivity of a system and subsequently system history outlines the future development. The reductionist approach tests hypotheses against causality independent of each other and systems are linear in the state of equilibrium. In complexity theory perception, systems are fundamentally non-linear and difficult to realise the cause and effect relationships. If projects are non-linear feedback systems with emergency aspect in which the whole is greater than the sum of its parts then the reductionist approach will direct to misleading analysis and conclusions (Stacey, 1996).

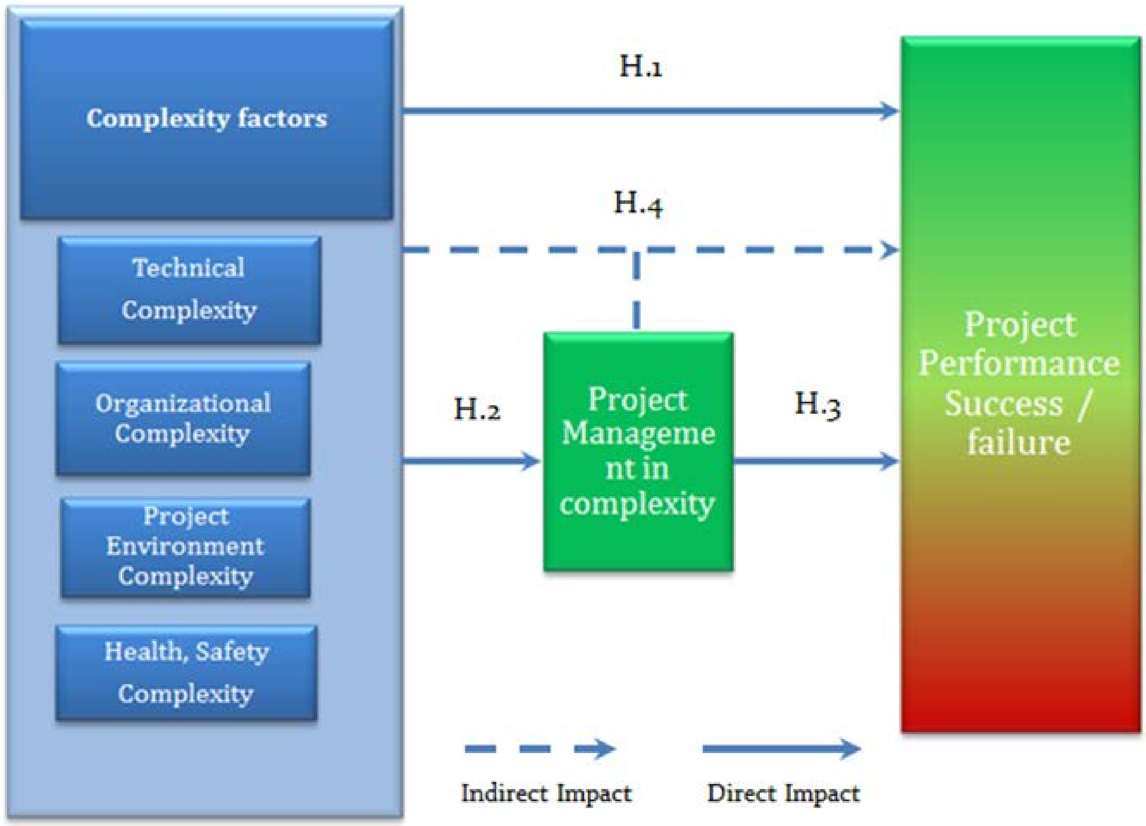


Figure 3-6 [Projects Complexity and Performance Model]

Firstly, we discuss the direct relation of Complexity factors and *Project Performance* in *H.1*.

***H.1* is stated in four sub-hypotheses as follows.**

H.1.1: There is relation between Technical Complexity and Project Performance at ($\alpha \leq$ 0.05).

H.1.2: There is relation between Organisational Complexity and Project Performance at ($\alpha \leq$0.05).

H.1.3: There is relation between "Project Environment Complexity ", and "Project Performance at (α $\leq$0.05).

H.1.4: There is relation between "Health, Safety & Environment Complexity ", and "Project Performance at (α $\leq$0.05).

Secondly, we discuss the direct relation of Complexity factors and Project Management in complexity in H.2.

H.2 is stated in four sub-hypotheses as follows.

H.2.1: There is relation between "Technical Complexity ", and "Project Management in complexity *at (α $\leq$0.05).*

H.2.2: There is relation between "Organisational Complexity", and Project Management in complexity *at (α $\leq$0.05).*

H.2.3: There is relation between "Project Environment Complexity ", and Project Management in complexity *at (α $\leq$0.05).*

H.2.4: There is relation between "Health, Safety and environment Complexity ", and Project Management in complexity *at (α $\leq$0.05).*

Thirdly, we discuss the direct relation between Project Management in complexity and Project Performance in H.3 will be tested.

H.3: There is relation between Project Management in complexity and Project Performance at (α $\leq$ 0.05).

Finally: H.4 is tested based on four sub-hypotheses.

H4.1: Project Management in complexity mediates the relation between "Technical Complexity" and "Project Performance at ($\alpha \leq$0.05).

H.4.2: Project Management in complexity mediates the relation between "Organisational Complexity" and "Project Performance at ($\alpha \leq$0.05).

H4.3: Project Management in complexity mediates the relation between "Project Environment Complexity" and "Project Performance at ($\alpha \leq$0.05).

H.4.4: Project Management in complexity mediates the relation between "Health, Safety and environment Complexity" and "Project Performance at ($\alpha \leq$0.05).

3.2.6. Limitations of the chosen research process

This section tackles the reliability and validity of selected research methodology. The question is how those approaches will meet the research study, how do questionnaires and interviews are the main sources of data is interpreted and analysed. Internal reliability concerns with reliability of methods are used within the research. Research measures to obtain internal reliability included systematic data gathering and processing. For external reliability, the criterion will be researching repeatability by means of tractability; this means that the research can be recreated by others.

The questionnaire contained points with a subjective nature. This is due to the difficulty of objectivity evaluating the complexity and its implications on project management. To support a situation questionnaire results will be compared with the whole project management societies though the results of meta-analysis findings plus interviews with selected portion of the whole sample.

3.3. Research Methodology

3.3.1 Introduction

Research is about developing knowledge in a precise field (Saunders, 2009). And researchers have long known that research methods impact construct measurements and that this impact or method bias, can lead to false conclusions. Method bias can lead researchers (1) to reject good ones and accept poor theories and (2) to base apparently practical suggestions on biased data (Burton-Jones, 2009). Effective research methods are essential to guarantee that research objectives can be accomplished while maximising the findings of the research (Ab-Rahman, 2011). The methodology the way in which the research is conducted, as means of supporting the philosophical assumption that underpins the research project (Quinlan, 2011) Research methods normally chosen before data generation and depends on aims, goals and the nature of research project (Reiter, et al, 2011). Many factors affect the selection of research methodology and among these factors are research topic, resources availability, data accessibility and availability, researcher expertise, and sponsor of the research (Al-qurtas and Zairi, 2003).

And for giving preliminary overview about research philosophies, research methodologies, strategies and data collection method see Figure 3.7 the methodological Pyramid, where showing that research philosophy support research methodology which supports the data gathering methods, for that must be a fit between these elements when the research is conducted.

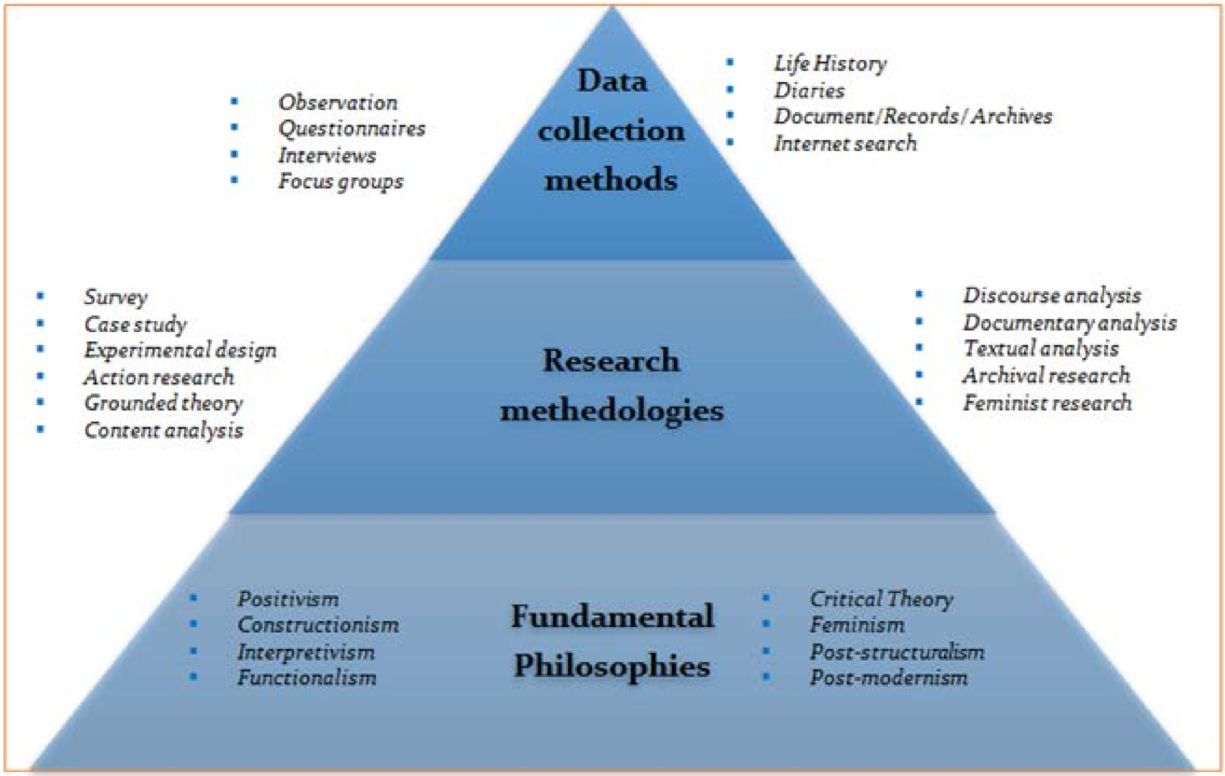


Figure 3-7 [The methodological pyramid (Quinlan, 2011)]

3.3.2 Overview of Research Philosophy

Usually, the implicit philosophical background affects the practice of research, so researcher views of the observed social phenomena should be considered in conducting a research, which leads to research paradigm to be followed, which in turn leads to appropriate research methodology (Wahyuni, 2012). How research should be accomplished is embedded in the philosophies of science, which assist in clarifying, and choosing a research design, there are three research philosophies, which are positivism, Interpretivism, and realism (Blomberg, et al., 2011). Quinlan, 2011 stated that social research paradigms are positivism, Interpretivism, and constructionist.

Meanwhile, Saunders, 2009 refer to positivism, realism, Interpretivism, and pragmatism as research philosophy. Empirical research in the field of extant business practices is accomplished in one or both of the interpretive and positivist research paradigms (Venable, 2011). So for the purpose of this study, the researcher will focus on the positivism and Interpretivism philosophies.

Positivist Philosophy

Positivism is a philosophy in conducting research adopted from the natural sciences. Its view of the relation between the theory and observation, is hypothesizing of a fundamental law is the start of theory development, and then research begins with the identifying causality shaping the base of fundamental law. And the research conducted to assess the observation fit with fundamental laws and to which range the causalities can be generalised. So knowledge develops through investigating the social reality by objective facts observation. For that positivists assumes that simple elements shape the social world which can be reduced, and the way of observing social world is by collecting objective facts. And for quantitative measurement of facts, the operationalised of concepts is needed (Blumberg, et al., 2011).

The basic principles of positivism philosophy are research is accomplished value free, the social world viewed objectively and exists externally, and researcher or observer is independent and his role is objective analysis Blumberg, et al, 2011; Al-qurtas and Zairi, 2003). And the process of knowledge attainment consists of deducting hypotheses and testing of those hypotheses through reality measurement, for that in positivist study quantitative methods are more followed (Blomberg, et al., 2011). Also, phenomena in social research can be broken down then studied, and the understanding of the phenomena will be from the elements study results (Al-qurtas and Zairi, 2003). So positivism adopted the objective or scientific approach and associated with quantitative methods, and statistics in social research (Quinlan, 2011).

Interpretivism Philosophy

Interpretivism claims that simple fundamental law is not enough for a full understanding of social phenomena; also, it is impossible to have an objective observation of the phenomena since social world is constructed by intentional actions and behaviour. The researcher is not independent rather involved and collaborate with a participant in address phenomena and try to supply and apply solutions, and for supplying interpretative explanation they pursue to understand the subjective reality. Interpretivism assumes that looking at the totality is the way to understand social phenomena and "the social world is observed through seeing the meaning people give to it and interpreting these meaning from their viewpoint". Social phenomena will not be disclosed be collecting and measuring facts. However, by making sense of how people interpret the social world, so interpretivism research is subjective. Moreover, they don't give big attention to the importance of generalizability of findings, meanwhile knowledge acquisition comes through deep level of phenomena analysis and investigation that lead to developing understanding of the phenomena, so qualitative method in interpretivism are more common

(Blomberg, et al, 2011). And social research with qualitative methods is related and conducted within an interpretive framework (Quinlan, 2011). Where the basic principles of interpretivism are: research is not value free but driven by interest, researcher involved and part what is observed, and the world is subjective and socially constructed (Blomberg, et al, 2011).

For distinction and comparison between the positivism and interpretivism philosophies, the following table 4.1 introduces the main basic principles and assumptions of these philosophies.

Table 3-2 [Comparison between positivism and interpretivism (Blumberg, et al, 2011)]

		Positivism	**Interpretivism**
Basic principles	View of the world	External and objective	Socially constructed and subjective
	Involvement of researcher	Researcher is independent	Part of what is observed and sometimes even actively collaborates
	Researcher's influence	Research is value free	Research is driven by human interest
Assumptions	What is observed?	Objective, often quantitative, facts	Subjective interpretations of meaning
	How is knowledge developed	Reducing phenomena to simple elements representing general laws	Taking a broad and total view of phenomena to detect explanations beyond the current knowledge

Justification of selection of positivism philosophy

The philosophy adopted impacted by the researcher view of the relationship between knowledge and the way or process of developing the knowledge (Saunders, 2009). This study set up from the positivism philosophy, since this study proposed a group of hypothesis about the relationship between project complexity and project performance (Success), and to stand on this relationship hypothesis must be tested, so the positivism is the appropriate philosophy since it is enabled conducting quantitative study, through enabling operational of terms and concepts which enable measurement. Also, this study pursues to generalise the result of the study at it is population through employing a large sample survey. There are three reasons that stand behind resorting to Positivism Research Approach as a suitable tool for conducting this research:

Firstly, the need to satisfy testing hypotheses and to verify relationships between variables that constitute the major content of the study, which cannot be attained using the Interpretivism, approaches. Therefore, the positivism approach is applicable to generate the research hypotheses depending on the research question that must be proved or disproved. The benefits of positivism approach are the speed in data collection, the simplicity of analysis, the suitability for testing hypotheses and determining relations between variables and establishing the reliability and generalisation of data.

Secondly, this thesis reports to the survey method as the main research strategy that aims at statistical significance, which is of positivism nature. Positivism approach aims at control and prediction through reduction of the problem to its essentials for theory testing and analysis. On the other hand, Interpretivism research aims at developing a detailed understanding of the problem in its full contextual situation. Positivists tend to use field experiments and surveys as research methods. They are looking for large amounts of empirical data that can analyse statistically to detect underlying regularities (Weber, 2004).

Finally, Positivists supposedly try to build knowledge of a reality that exists beyond the human mind. They apparently believe that human experience of the world reflects an objective, independent reality and that this reality provides the foundation for human knowledge (Weber, 2004). On the other hand, Interpretivism recognises that the knowledge they build reflects their particular goals, culture, experience, and history, in order to try making sense of the world (Weber, 2004). Based on the above reasons, this thesis adopts the positivist approach. Having discussed the reasons for selecting the positivism research approach, the Research Purpose is described in the next section to identify ways to carry out the objectives of this thesis.

3.3.3 Research Purpose

The main objectives for which research is generally undertaken are description of a phenomenon and its connections with other phenomena, explanation of causal relationships among phenomena, and deep understanding of phenomena (Marais, 2012). Purpose and technique are the bases in classifying business researchers, the research purpose and the nature of decision situation impact the research methodology of the research. And for gaining useful research results, must match decision situation with the proper type of research (Zikmund, et al., 2013). The main types of business researchers are exploratory, descriptive, and causal or explanatory research (Zikmund, et al., 2013; Blumberg, et al, 2011).

Exploratory

This type of research is beneficial when the researcher does not have a clear idea of the problem. So through exploratory research, the researcher can develop a clear concept, develop an operational definition, build priorities, and enhance final research design. This type of research may save money and time; due to it is exploring the role, so in case the problem or the dilemma in the study is not significant this will lead to the cancellation of the following studies (Blumberg, et al, 2011; Cooper and Schindler, 2008). Exploratory research can be employed in the case of the need to do an exploration to know about new or unclear management dilemma. Also, variables in this kind of studies could be not known or not defined also hypotheses may be required. For completion of the objectives in exploratory research, quantitative and qualitative techniques can be used, but it relies on qualitative technique more (Blumberg, et al, 2011). Zikmund, et al, 2013 stated that exploratory research is employed for potential opportunities discovery or clarifying the unclear situation, and normally this type of research is the first step used to guide following studies.

Descriptive

Many social scientific projects, including management and business studies, have the main goal of describing a phenomenon (e.g. how many occurrences of the phenomenon exist in a population as found in a survey). Inductive theories normally surface from such research (Marais, 2012). Descriptive study concerned with finding out what, where, when, how much, or who, (Blumberg, et al, 2011; Zikmund, et al, 2013). These types of studies is more formalised than exploratory studies, encompass investigative questions or hypotheses, and may serve different set of research objectives such as, phenomena description, characteristics of related population and its proportion, and correlation studies through discovering the association between variables (Blumberg, et al, 2011). And might be doing a classification or developing a theory which is in nature purely factual Venable, 2011)

Zikmund, et al, (2013) stated that descriptive study main purpose to describe characteristics of organisations, groups, people, object, and environment, and this study directed toward definite issues. At the same time, descriptive study does not explain why the variables interact in such way or why the event has occurred (Cooper and Schindler, 2008).

Causal (Explanatory)

Causal research is concerned with how one variable lead to changes in another variable; this means that it is a concern with learning why so it is an emphasis on an attempt to explain the relationship between variables. And causal research can be qualitative and quantitative research (Blumberg, et al, 2011). Normally in quantitative research, hypothetic-deductive theories come out from this type of research design (Marais, 2012). Explanatory concerned with studying phenomena to explain the relationship among variables (Saunders, et al, 2009). So this type of research looking for identifying the cause and effect relationship and for conducting causal research, the researcher must have a full understanding of the phenomena. Descriptive research shapes the basis for causal research through providing a better understanding of the phenomena under study (Zikmund, et al, 2013). Also, explanatory research concerned with correlational studies, and pursues to explain the reasons for the phenomena, so researcher uses hypotheses and test these hypotheses to point out the variables caused specific phenomena (Cooper and Schindler, 2008).

Justification of selecting descriptive and Causal "explanatory"

This research conducted based on descriptive and explanatory research purpose, since the researcher pursues to deepening the understanding of the topic in the study, through reviewing related literature, describing the variables of the study, testing hypotheses, and analysing data for describing the relationship between project complexity sources and project success.

The research purpose and research questions reveal that this study is descriptive because the related data will be collected and analysed to verify the hypotheses of the research. Also, the data collected will be used to describe the area of research and draw some conclusion. It is also explanatory because the researcher develops hypotheses to be tested and then examines whether the data collected can be called on to support or refutes those hypotheses, which will be used to explain the relationship between variables related to project management process and complexity process to propose Complex Project Model.

Based on the above reasons, the descriptive and explanatory research is selected for the present thesis. The next step after setting a research purpose is to connect it with actual practice. The purpose of a study can be served in different ways depending on what research approach the investigator chooses to apply. This is carried out by describing how to conduct the research that contains the Research question and research Hypothesis. Accordingly, the following section will focus on the nature of quantitative and qualitative research approaches. Also, it discusses the relevance of these approaches to the current research and proceeds to suggest the suitable techniques for the current research.

3.3.4 Research Approach

There are many research approaches or methods which could be classified into two main categories, the first one is qualitative, inductive, holism, phenomenology, and case study main while the other category is quantitative, positivism, reductionism, scientific, and hypothetic-deductive, and procedure not quality is the main difference between quantitative and qualitative research (Al-qurtas and Zairi, 2003). In some cases, the researcher can use the hybrid way through combining both quantitative and qualitative method in one research, where qualitative to make clear problem through separate the problem from it is symptoms then will follow up with a quantitative method to make test of the relationship between variables (Zikmund, et al, 2013). The quality of research depends on how well it is conducted and quality of it is design not on either the research is qualitative or quantitative (Blumberg, et al, 2011).

Qualitative Research

Qualitative research: Research that addresses phenomena from the viewpoint of the insider or subject for understanding the phenomena in their natural context is qualitative research. This approach employs qualitative indicators such as stories, pictures, words, … as non-numerical information on phenomena; its methodologies are normally more comprehensively recorded, less formalised, rigid, specific and explicated (Marais, 2012). Qualitative business research is research that deals with business objectives without depending on numerical measurement through a technique that allows the researcher to present elaborate interpretation of market phenomena (Zikmund, et al, 2013). Qualitative methods refer to the metaphors, or definitions, models, analogies that characterise things, based on 'quality' and it is descriptive and more to the explanation of ' the ‘meaning' of phenomena under the study. It is less structured, open and more focused on the process, it does not concentrate on the numerical data. The scope of method covers a small number of respondents (Ab-Rahman, 2011).

A question of qualitative research should explore a qualitative argument in a qualitative manner. The question has to be clearly explained which means that it is important to make every part of the question as obvious as possible the methodological choices: which case(s) are chosen; how the information is gathered; and how the type of data analysis is selected (Cresscentini, 2009). Qualitative research methods have been introduced in social science to enable researchers to study cultural and social phenomena. Interpret and disclose concepts and meanings rather than generalizing accidental relationships are qualitative research strategies. Qualitative research techniques can’t be into numbers (Eshlaghy, et al, 2011).

Qualitative methods concentrate on its analysis of data on the qualitative way for that the sample size is small for achieving the in-depth analysis (Al-qurtas and Zairi, 2003). Qualitative study relies on qualitative information's (Blomberg, et al, 2011) and more employed by exploratory studies, interpretive which need subjective judgment, small sample, and unstructured format of interview, which make it difficult to test hypotheses with qualitative research, so qualitative research is researcher dependent (Zikmund, et al, 2013).

Quantitative Research

Quantitative research: Research that addresses phenomena from the viewpoint of the outsider in order to predict and explain the phenomenon under study in isolation is quantitative. This approach employs numerical indicators of abstract concepts; its methodology is normally relatively rigid, formalised, explicated and cross-referenced, but more recorded by means of statistics (Marais, 2012). And the developments in quantitative methods continued to become increasingly sophisticated as the advance of software packages and technology enabled the analysis of complex sets of statistical data (Lee and Cassell, 2013). Quantitative research is normally associated with experiments relating numeric and statistical data (Ab-Rahman, 2011).

The quantitative method concentrates on the analysis of the relatively big volume of descriptive or numerical data and extensively applying statistics (Al-qurtas and Zairi, 2003). Also, the kind of information employed to study a phenomenon is the main distinction between qualitative and quantitative research (Blomberg, et al, 2011). Quantitative research traditionally concerned with research control, collection of objective data, and development of standardised and systematic procedures (Kelemen and Rumens, 2012)

Research that addresses research objectives through empirical assessments including numerical measurement and analysis approach are quantitative research. In addition, it tests specific research questions and hypotheses; it is the common purpose of quantitative research. Moreover, to use structured data collection approach, where the researcher is independent and objective so the result of the research also objective, and for generalizability of result quantitative research use large sample, and most employed in both descriptive and causal or explanatory research (Zikmund, et al, 2013).

Justification of selecting combined research approach

The quantitative approach is more appropriate if the study has a large number of respondents, meanwhile qualitative approach is chosen if we just choose a small number of respondents (Ab-Rahman, 2011). The preference for the employment of qualitative or quantitative methods reflect researcher view on knowledge and science, for that the choice between the two methods is epistemological issue related to research philosophy, also research problem, purpose, information kind and accessibility to this information playing a role in the choice between qualitative and quantitative approach (Blomberg, et al, 2011). Qualitative and quantitative methodologies are usually associated with the phenomenology and positivism research paradigms (Mangan, et al, 2004).

There are three reasons for resorting to combined approach as being suitable for this research. Firstly, the aim of this research is to propose a conceptual model describing an integrated model for project management process and complexity theory in order to improve complex project performance or success. Therefore, Quantitative research is employed in the study hypothesis that should be proved or disproved. This research begins with a model of the research of interested, then with the specific hypotheses that can be tested. This ultimately enables us to test the hypotheses with specific data that could result in confirmation or verification of our original theories drawing on the whole research approach with deductive feature

Secondly, quantitative research approach tends to support the positivist philosophy. The researcher uses the statistical techniques to identify facts and causal relationships among variables. Samples can be larger and more representative. Results can be generalised to larger populations within known limits of error. The data collection in quantitative research is structured and data analysis is statistical. Quantitative research uses numbers and measures things. The utilisation of consistent methods in quantitative research allows for greater objectivity and accuracy of results. Normally, quantitative approach is designed to provide summaries of data that support generalisations about the phenomenon under study. In contrast, a qualitative approach is more beneficial than Interpretivism philosophy. In a qualitative approach, the results cannot be generalised and the data collection in is unstructured and data analysis non-statistical.

Finally, the quantitative approach is usually applied when the purpose is to verify existing theories or test hypotheses developed depending on the previous research. The major benefit of the quantitative paradigm is the possibility for gaining an objective and precise assessment of the social phenomenon or human behaviour. In contrast, the Qualitative approach is preferable in the case of exploratory study or if little theoretical understanding of the phenomenon exists. The qualitative approach provides the possibility for exploring the phenomenon, going into greater depth in studying the research problem and eventually developing a basis for concepts or theories. The main disadvantages of the qualitative method include the subjectivity and narrative nature of the argument, which feeds into the belief that validity and reliability in qualitative research are difficult to address.

Based on the above reasons, a quantitative approach is selected for the first phase of this thesis in the questionnaire process while the qualitative approach will influence the interviews process in the second phase. The following section will summarise the overall research strategy in the complex projects management environment.

3.3.5 Research Strategy

Saunders, et al (2009) refers to experiments, survey, case study, grounded theory, archival research, ethnography as research strategies, and research strategy employed or used in research will be guided by research objectives, questions and philosophy. Quinlan (2011) stated that there are many methodologies employed for conducting a research such as experimental design, case study, survey, action research, Meta-analysis, ethnography, grounded theory, semiotics, and so on.

Case Study

An experimental inquiry that explores a phenomenon within its real-life context, as the boundaries between context and phenomena are not obvious, and in which multiple sources of evidence are employed (Yin, 2008). The case study has been increasingly used in researches especially in small scales as a research strategy in social studies. Case study concentrates on one case or a small number of cases of a particular phenomenon. Case study pursues to investigate deeply the relationship between phenomena, processes or experiences happening in a special sample. Furthermore, can be used as a preferable strategy when a research has a low control on events and the emphasis is on contemporary phenomena in real life (Eshlaghy, et al, 2011).

Case study is one of qualitative research method applied in social sciences. it concentrates on in-depth understanding of limited number of cases (Al-qurtas and Zairi, 2003) Qualitative case study could be descriptive or causal, if it is focusing on reporting what has been observed it is a descriptive case study, but if it is emphasis to present new theoretical explanation through exploring the case will be causal case study. Case study results can be generalised to a theoretical proposition but not to a population (Blumberg, et al, 2011). Case study is the in-depth study of a specific bounded entity that could rely on qualitative, quantitative data or hybrid of both (Quinlan, 2011).

Experiment

Experiment is a cautiously controlled study in which the researcher manipulates a proposed cause and observes any resultant change in the proposed effect (Zikmund, et al, 2013). In this type of research, the researchers try to manipulate or control the variables in the study, when researcher wants to discover whether certain variable (independent variable) produces impact in other variables (dependent variable). Experiment is the proper methodology for causation establishment, but the number of variables in experiment studies limited more than other studies such as survey research for that experiment is more suitable for studies with few influential factors (Blumberg, et al, 2011). True experiment rarely employed in social science and project management research since it is not easy to control all the variable of the phenomena (Quinlan, 2011).

Survey (Questionnaire)

Survey is a research design concern with a big sample and cross-sectional study takes the world as it comes without intervention, employ observation or questionnaire for data collection (Gaski, 2013). Survey is the common approach used to learn much about attitude and opinions (Blumberg, et al, 2011). Survey is a research technique in which a sample under study is interviewed or the behaviour of respondents is observed in some way described. It is also used for primary data collection in business research the common method is surveyed, at the same time in survey the participation of the respondent is needed, and the more formal term of survey is sample survey, although the majority of survey accomplished to quantify specific information. Also, the survey provides an inexpensive, quick, accurate and efficient means of assessing information regarding population (Zikmund, et al, 2013).

Survey could be classified as structured or unstructured depend on the degree of structure, also could be classified as mail survey, internet survey and telephone survey depend on communication method, disguised or undisguised based on degree of question disguise, and cross-sectional study or longitudinal studies based on temporal classification time frame (Zikmund, et al, 2013). Normally the sample in a survey is big, relaying in using scale or questionnaire methods for primary data collection, and tend to be quantitative research (Quinlan, 2011).

There are two types of questions, which can be used in surveys: (1) Open-ended questions, which allow to respondents to answer the questions in any way they prefer

(2) Closed questions, in which, the respondents asked to make choices among a set of choices given by researcher (Sekaran, 2006).

Interview

In Interviewing, the data is collected by referring to interview respondents in order to obtain data or information on the issues of interest. There are two categories of an interview, which are an unstructured or structured interview, and they can be conducted either face to face or by calling the respondents. The advantage of the interviewing is that its flexibility in terms of adapting, and changing the questions (Sekaran, 2006).

i. Unstructured Interviews:

It refers to Interviews where the interviewer does not start the interview with a planned order of questions to be asked to the respondent. The objective of the unstructured interview is brought to the surface some preliminary issues that based on these issues the researcher can specify which variables need additional in-depth analysis. Also, the researcher should interview several levels of employees to understand the situation in its total. By conducting the unstructured interviews, the researcher will be able to start in conducting the structured interview as the researcher identified the variables that need more in-depth analysis (Sekaran, 2006).

ii. Structured Interviews:

When the variables that need more in-depth analysis are identified, the researcher conducts the structured interviews. Also, in this type of interview the researcher has a list of pre-planned questions to be asked (Sekaran, 2006).

Table 3-3 [Comparison between different types of Interviews and Questionnaires (Sekaran, 2006)]

Mode of data collection	Advantages	Disadvantages
Personal or Face- to-Face Interviews	▪ Can establish rapport and motivate respondents. ▪ Can clarify the questions, clear doubts, add new questions. ▪ Can read nonverbal cues. ▪ Can use visual aids to clarify points. ▪ The Rich date can be obtained. ▪ CAPI can be used and responses entered in a portable computer.	▪ Takes personal time. ▪ Costs more when a wide geographic region is covered. ▪ Respondents may be concerned about the confidentiality of information given. ▪ Interviewers need to be trained. ▪ Can introduce Interviewer biases. ▪ Respondents can terminate the interview at any time.
Telephone Interviews	▪ Less costly and speedier than personal interviews. ▪ Can reach a wide geographic area. ▪ Greater anonymity than personal interviews. ▪ Can be done using CATI.	▪ Nonverbal cues cannot be read. ▪ Interviews will have to be kept short. ▪ Obsolete telephone numbers could be contacted, and unlisted ones omitted from the sample.
Personally Administered Questionnaire	▪ Can establish rapport and motivate respondent. ▪ Doubts can be clarified. ▪ Less expensive when administered to groups of respondents. ▪ Almost 100% response rate ensured. ▪ The anonymity of respondent is high.	▪ Organisations may be reluctant to give up company time for the survey with groups of employees assembled for the purpose.
Electronic Questionnaires	▪ Easy to administer. ▪ Can reach globally. ▪ Very inexpensive. ▪ Fast delivery. ▪ Respondents can answer at their convenience like the mail questionnaire.	▪ Computer literacy is a must. ▪ Respondents must have access to the facility. ▪ Respondent must be willing to complete the survey.

Justification of selecting Survey and Interviews strategy

Survey and Interviews research strategy was employed in this research, since both normally used with deductive approach, and it is the most used approach in management and social research. They enable the researcher to collect quantitative data that can be statistically analysed. Also, the collected data enables the researcher to use and suggest possible reasons behind specific relationship among variables, and achieving results that are representative of population (Saundres, et al, 2009). Survey enable representation of population through reach to a big number of respondents and gathering a big volume of quantitative data, which enable generalizing of research findings and results. And since this study will measure the perceptions of the respondents so survey strategy is the most appropriate through employing scaled instrument for data collection.

3.3.6 Research Design

The research design is the blueprint for achieving objectives and answering questions. Design selection could be not easy by the availability of a large variety of methods, procedures, techniques, sampling plans, and protocol (Blumberg, et al, 2011; Cooper and Schindler, 2008). And the approach employed to collect primary data could be used to classify research design also types of needed information for conducting the research lead to the determination of data collection approach (Blumberg, et al, 2011). Research design refers to a master plan that identifies the methods and procedures for collecting and analysing required information, so research design includes information sources, technique, and sampling methodology (Zikmund, et al, 2013). Research Design is the systematic plan to be followed to answer the research question, it encompasses research question formulation, identifying and gathering data, statistical method selection, analysing, interpret and report research results (Wiersema and Bowen, 2009).

Data Collection

There are two ways for data gathering which are secondary data and primary data. Whereas secondary data is data or information that has been gathered and recorded by someone other than the researcher for other objectives (Blomberg, et al, 2011; Zikmund, et al, 2013). and the source of this information can be external or internal, written and electronic, the internal source of secondary data are the data or information that available for organisation members such as databases and information systems, memos, invoices, accounting records. The external source of secondary data related to all the data available outside the organisation such as government, publishers, trade association, media sources, commercial sources (Blomberg, et al, 2011) also availability, saving time and money is the main advantages of secondary data. However, this available data could be not enough or sufficient for the study aim and objectives (Blomberg, et al, 2011; Zikmund, et al, 2013). Secondary data assist in model building through its help in identifying relationships among two or more variables (Zikmund, et al, 2013).

Meanwhile, the primary data could be collected by observing behaviour, people, events, conditions, or by communication approach, which encompasses interview either personal or telephone interview and self-administered inquiry (Blomberg, et al, 2011). Communication approach for primary data collection could be through personal interview, phone interview, self-administered questionnaire (Blomberg, et al, 2011; Zikmund, et al, 2013).

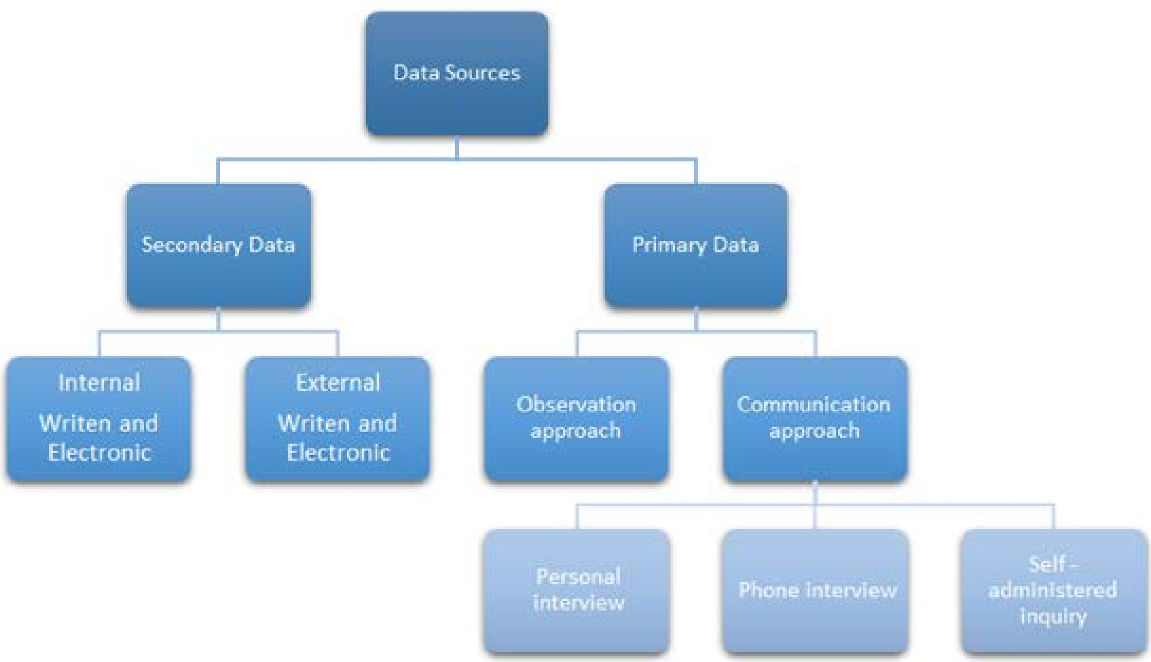


Figure 3-8 [Data Source (Blumberg, et al, 2011; Zikmund, et al, 2013)]

Questionnaire Design

In this research, the Questionnaire is used to identify how project managers in oil and gas industry see and face complexity in projects. The questionnaire consists of a list of clear and structured questions based on the previous studies, aiming to discover or test connections between different types/sources of complexity and projects success/failure based on the selected group experience and believes. Closed-ended questionnaire type selected

A self-administered questionnaire with closed-ended questionnaire type selected as a method for collecting primary data where the respondents carry the responsibility for both readings and answering the stated question in the on-line questionnaire. Questionnaire question developed to identify the required data to address the research inquiries, at the same time take in the consideration the issue of reliability and validity of collected data and information.

Going along with positivism philosophy, descriptive and explanatory purpose, quantitative method, and survey strategy for collecting primary data questionnaire is the most appropriate. Questionnaire through using scaling enable collection of quantitative data, which can be used in the statistical analysis of data, which enable describing, and explaining the relationship and impact among the variable.

The questionnaire starts with a description of the meaning of the main concepts, and then illustrates the instructions on the way to answer each section of the questionnaire. An initial draft of the questionnaire was developed based on an extensive literature review. The questionnaire includes many questions, which are in line with the research that aims at achieving several objectives. Therefore, the research survey could be described as being comprehensive. The questionnaire is divided into two parts. The first part includes personal information of the respondents such as age, gender, the area of profession, and years of experience. The second part includes the questions related to complexity factors that affect the project management performance to produce the complex project management model.

Pilot Test

Prior to using the questionnaire to collect data researcher did a pilot test. The reason for conducting such a pilot test was to enhance the questionnaire so that respondents will not have difficulties in answering the questions or recording the data (Saunders et al., 2009). A pilot test was conducted to reduce any misunderstanding or ambiguous questions and procedures that will be used in performing the survey that may influence negatively the data analysis. In addition, it will enable obtaining some assessment of the questions validity and the expected reliability of the data that will be collected (Saunders et al., 2009). Moreover, the pilot study has provided information about the response rate and helped in determining the appropriate data collection method in terms of both content and data procedure. This helps the researcher develop and test the adequacy of the questionnaires.

To achieve the internal validity of a questionnaire, the researcher focuses on the following aspects of the process: Asking the participants about their comments to identify vagueness and difficult questions to complete the questionnaire and decide whether it is reasonable and to test its level of comprehension regarding the wording of questions.

The questionnaire was a pilot test on the participants in ADNOC Subsurface & Drilling Technology Conference 2013. Fifteen completed questionnaires were received out of 73 questionnaires distributed to the managers attended the presentation conducted by the researcher three-time on January 30th 2013 in Abu Dhabi (United Arab Emirates) under the title (**'On the edge of chaos': Does complexity theory offer solutions to improve clients' value expectations of oil and gas projects?**).

Table 3-4 [ADOC Subsurface & Drilling Technology Conference 2013 Agenda]

ADNOC Subsurface and Drilling Technology Conference, January 30-31, 2013.

DAY 1	Booth 5	Booth 6	Booth 7	Booth 8	Booth 9	Booth 10
Session A	Geomechanics	Reservoir Management	Maximising recovery	Gas / unconventionals	Digital rock physics / micropilot	Well interventions
Presentation 1 09:00	SCHLUMBERGER : Applications of Coupled Reservoir Geomechanical Modeling to Fractured Carbonate Reservoir Deformation and Performance	ZADCO : Waterflood Management Practices Using Integrated Sector and Well Performance Analysis	ADCO : CO2 programs	BP : Finding Sweet Spots in Shale Gas and Liquid Plays	TOTAL : Digital Rock Physics for estimation of petrophysical properties: history of a decade of technology utilization, follow up and assessments	ADCO : Rigless solutions
Presentation 2 09:30	SCHLUMBERGER : 3D Geomechanical Modeling and Wellbore Stability Analysis in Abu Butabul Field	ADNOC : Assessment of Applied Effective Reservoir Management Practice In Giant Offshore Carbonate Oil Reservoir Lessons Learned and Risk Control	ADCO : WAG optimization	Al HOSN : Game Changer design of 2 3/8" Coil Tubing pipe & placement technique for matrix stimulation of Extremely sour high temperature Arab formation OH laterals.	ADCO : Using DRP (Digital Rock Physics) & Duel Energy Tomography in ADCO	BAKER : Surface controlled SSSV
Presentation 3 10:00	SCHLUMBERGER : Pore Pressure Prediction Challenges in the Middle East Region	ADNOC : Assurance Of Effective Reservoir Management Strategy In Giant Offshore Mature Carbonate Oil Reservoir With Huge Gas Cap - Lessons Learned And Risk Control	ADNOC : Lessons Learned Based On Ten Years Of Gas Injection Pilots Performance In Giant Offshore Carbonate Reservoirs - New Concept Of Assessment Process	WEATHERFORD : "On the edge of chaos": Does complexity theory offer solutions to improve clients' value expectations of oil and gas projects?	ADCO : Micro-pilot tool application	ADMA : rigless innovative practice to restore well productivity

The pilot study was used to test model and research techniques. That will be used to further collection and analysis of data. In this research, a pilot study is employed to determine whether the conceptual model identified in chapter 3 is prevalent in practice, and to investigate whether some of the testing model and research methodology developed for the research are suitable or require changing. Based on the feedback from the pilot study test, a few questions on complexity factors were strictly relevant to oil and gas industry was added.

The main benefit of the pilot study is that it provided the researcher with a preliminary indication of the influence of the proposed conceptual model to identify how an oil and gas projects in MENA deals with complexity, understand complexity sources/factors, cope with existing complexity in projects, and describing how industry deals with the complexity in the future.

The following questionnaire in Table 4-3 was built based on the pilot test distributed in ADOC Subsurface & Drilling Technology Conference 2013, plus the discussion with oil & gas leadership in MENA on (1) 18th Middle East Oil & Gas Show and Conference (2) Abu Dhabi International Petroleum Exhibition & Conference. (3) 3rd Erbil International Oil & Gas Exhibition (4) ADOC Subsurface & Drilling Technology Conference 2013 (5) Technical days in Oman, Pakistan, Iraq, UAE, Saudi, Kuwait, Qatar, India, Algeria, Yemen, and Libya.

Technological, Organisational and Environmental (TEO) developed by Rekveldt et al. (2011) were adopted as the base for questionnaire structure to insert the factor mentioned above plus factors adopted by different researchers on chapter 2:

Table 3-5 [Adopted Management of project in Complexity Questionnaire]

Categories	Factor
Technical	Goal alignment
	Clarity of goals
	Quality requirements
	Project Team competency "Technical prospective"
	Technical complexity
Organisational	Financial risks
	Project leadership
	Projects management complexity
Project Environment	Safety of environment (Region, country, or city)
	Political Stability of environment (Region, country, or city)
	Instability of Oil Prices
Health, Safety, & Environment (HSE)	Operational risks affecting processes and people
	Corporate environmental responsibilities
	Project location safety and security concerns
Project Management in Complexity	Dependencies between tasks
	Interdependency between used Technologies
	Compatibility of different pm methods and tools
	Interfaces between different disciplines
	Number of different cultures
	Interdependence with other projects within organisation

	Communication within project teams and stakeholders
	Project Environment change
	Interaction with governments and regulatory bodies
	Media influence

Sample Selection

Identifying and selecting a sample is one step in planning the research design, so researcher must determine who and how many participants to be involved. And where sample refers to as a part of the chosen population, it should be selected in a way that represents the study population (Blumberg, et al, 2011). The main sampling plan techniques are probability sample and non-probability sample (Blumberg, et al, 2011; Zikmund, et al, 2013). Probability sampling refer to the true random selection process, and each member in the population has a known, nonzero probability of chosen, meanwhile non-probability sampling refers to personal judgment in sample selection process, and each member has an unknown probability to be chosen in the sample (Zikmund, et al, 2013). Probability sampling means that each individual, case element of the population has an equal probability of being chosen (Quinlan, 2011). Whereas probability samples are simple random sampling, systematic sampling, cluster sampling, stratified sampling, and double sampling, secondly the non-probability samplings are convenience sampling, purposive sampling (judgment), and snowball sampling. Figure 4.3 shows sampling approaches based on Blumberg, et al (2011);

Zikmund, et al, (2013) classification followed by discussion and a brief summary of the different types of samplings.

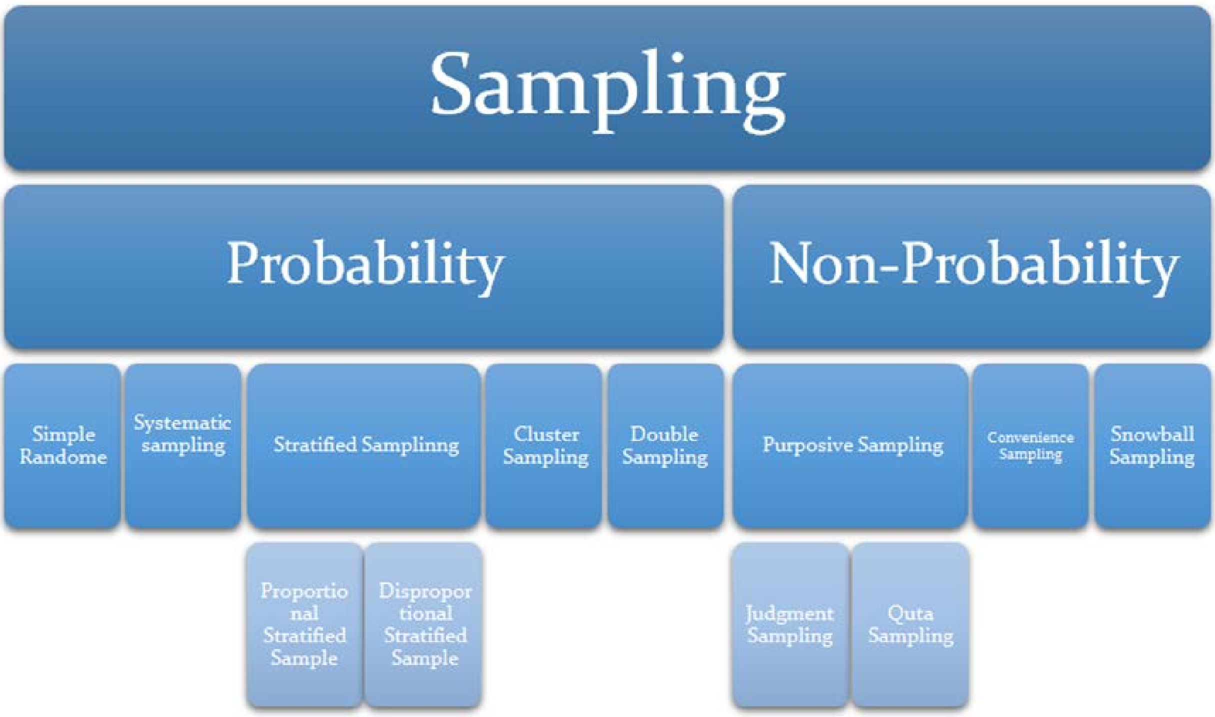


Figure 3-9 [Sampling Approaches (Blumberg, et al, 2011; Zikmund, et al, 2013)]

Firstly, non-probability sampling, convenience sampling refers to obtaining the most available conveniently analysis unit, and this type used by researchers to obtain quickly and large number of completed questionnaire, and at a low cost, but the respondent or the sample is not representative, also this type best employed by exploratory research (Zikmund, et al, 2013). It is the easiest and cheapest to conduct but is the least reliable (Blumberg, et al, 2011). Snowball sampling refers to the procedure in selecting initial sample by probability sampling and then chosen additional sample based on the information obtained from the initial respondent (Zikmund, et al, 2013). Therefore, this type is best utilised to locate units of difficult or rare population by referrals (Zikmund, et al, 2013; Blumberg, et al, 2011), and this type is appropriate in cases where generalisation is not expected (Zikmund, et al, 2013). Purposive sampling, which is non-probability sampling, divided into judgment and quota sampling (Blumberg, et al, 2011). Judgment sampling, researcher select a sample based on a personal judgment about some suitable characteristics of sample members that will satisfy researcher specific objectives, even if the sample is not fully representative. Quota Sampling is a non-probability sampling procedure, that ascertain that different subgroups of a population will be represented by pertinent characteristics to the exact range that the investigator or researcher desires, so the respondent selected in convenience sampling procedure (Zikmund, et al, 2013)

Secondly probability sampling, which is free of the inherent bias in the non-probability sampling procedures, where simple random sampling procedure ascertain that elements in the population have an equal chance to be in the sample selected (Zikmund, et al, 2013; Blumberg, et al, 2011). And systematic sampling refers to a procedure in which the starting point in sample selection is selected randomly and then every nth (Kth) number selected from the list (Zikmund, et al, 2013; Blumberg, et al, 2011), involve selecting from the sampling frame and items at regular or systematic intervals (Quinlan, 2011). So it is not actually random selection procedure but lead to random results if the item arranges randomly in the list (Zikmund, et al, 2013). A stratified sampling is a probability sampling procedure in which subsamples that are less or more equal on some characteristics are drawn from within each stratum of the population, stratified sampling could be proportional stratified sample. However, sample drawn from each stratum is in proportion to the stratum population size and disproportional stratified sample where the sample size of each stratum allocated based on analytical concerns (Zikmund, et al, 2013). Blumberg, et al, (2011) stated that stratified divides the population to strata or sub-populations and apply simple random on each stratum, and the result may be weighted and combined.

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Cluster sampling is a type of sampling method in which the primary sampling units is a large cluster of elements not the individual element in the population, then the cluster randomly selected, the most popular type of cluster sampling is the area sample (Zikmund, et al., 2013). and in the cluster, the population is divided into heterogeneous sub-groups (Blumberg,et al., 2011) Whereas the final type of probability sampling is multistage area sampling which is involves using a mixture of two or more probability sampling techniques (Zikmund, et al, 2013). And Blumberg, et al, 2011 refers to it as double sampling which is a process that collecting data from a previously defined technique, and depend on the information found, a sub-sample is chosen for additional study, and this type of sampling is usually found with cluster or/and stratified designs.

Justification of Snowball sampling selection

To ensure obtaining a more efficient sample, through leading to a smaller standard error and ascertain that the sample reflects and represent the population. Snowball Sampling is chosen to select the sample from the population of the study for ensuring that the sample is representative then can generalise the results to the population of the study since the oil and gas industry in MENA contains many districts, operating companies and service companies. Yet the initial contact will be the most important in order to identify proper contacts (sample) in order to avoid bias.

Sample Size

Sample size, in reality, is a function of the variation in the accuracy needed by the researcher, and population characteristics in the study, for that sample size impacted by some principles: Degree of heterogeneity in population under study, desired precision, number of subgroups of interest, the sample size will be large or small depended on of those factors. To be representative sample must be large (Blumberg, et al, 2011).

The sample size is specified by:

(1) The estimated variance of the population.

(2) The magnitude of acceptable error.

(3) The confidence level" (Zikmund, 2003).

The Society of Petroleum Engineers (SPE) which is covering members of organisations and serving as managers, engineers, scientists and other professionals worldwide in the upstream segment of the oil and gas industry.

Location of Professional Members by SPE Region						
SPE Region	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**
Africa	2,958	3,315	3,768	4,321	4,822	3,874
Canada	4,932	5,383	5,834	6,240	6,186	5,384
Eastern North America	3,691	3,941	4,105	4,261	4,217	3,628
Gulf Coast North America	15,305	16,330	17,416	17,862	18,166	16,027
Mid-Continent North America	6,102	6,467	6,752	6,941	6,935	6,054
Middle East	10,624	12,778	11,214	11,912	14,107	14,538
Northern Asia Pacific	5,690	5,868	6,197	6,892	7,105	6,277
North Sea	7,699	8,244	8,385	8,725	8,742	7,805
Rocky Mountain North America	3,070	3,270	3,524	3,594	3,560	3,124
Russia & Caspian	1,599	1,603	1,978	2,068	2,822	2,908
South America & Caribbean	2,347	2,523	2,608	3,718	5,601	5,887
South Asia			2,314	2,571	3,223	--
South Asia and the Pacific						7,082
South Central & Eastern Europe	3,143	3,159	3,419	3,871	4,137	3,650
Southern Asia Pacific	3,368	3,420	3,596	3,743	3,731	--
Southwestern North America	2,503	2,828	3,077	3,302	3,250	2,973
Western North America	2,442	2,636	2,624	2,644	2,489	2,113

Figure 3-10 [SPE Membership Demographics (SPE Annual Reports, 2016)]

While this figure (3-10) covers professional members as managers, engineers, and scientists, it also includes students and entry level professional members. The percentages varies from region to region for example its around 31% for Middle East and 18% for Russia and Caspian. Figure (3-11) following graphics of how SPE membership has changed over time.

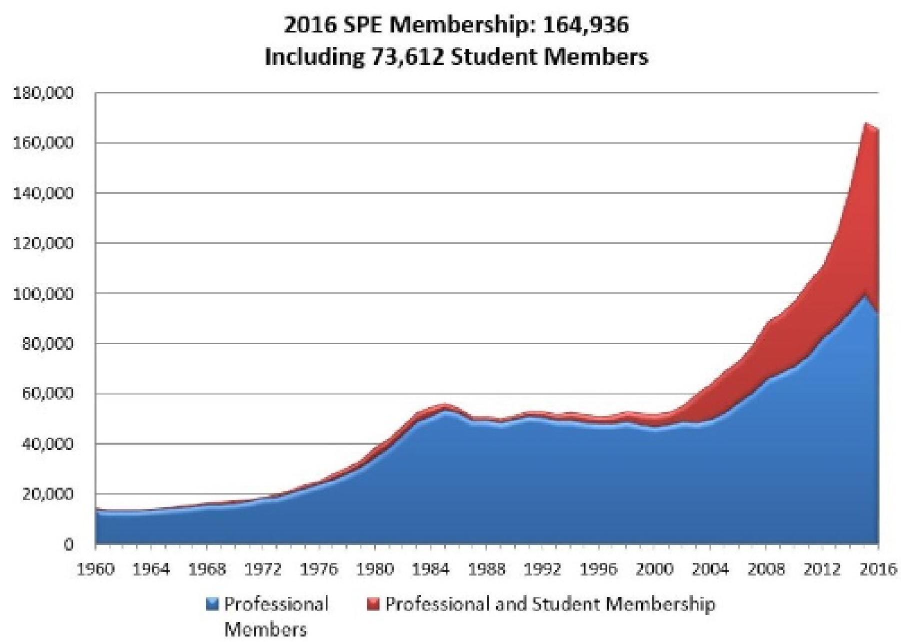


Figure 3-11 [SPE Membership Demographics (SPE Annual Reports, 2016)]

Based on those facts and numbers table below show estimated sample size based that need to be surveyed to get precise and reliable findings; based on the Confidence Level of 95% and SPE population of 11,200 SPE Petroleum Engineers.

Table 3-6 [Research Sample Size Selection]

	SPE Members 12,778 (2012) 11,214 (2013) P SPE Members 8,816 (2012) 7,737 (2013)	SPE Members 12,778 (2012) 11,214 (2013) P SPE Members 8,816 (2012) 7,737 (2013)	SPE Members 12,778 (2012) 11,214 (2013) P SPE Members 8,816 (2012) 7,737 (2013)	SPE Members 12,778 (2012) 11,214 (2013) P SPE Members 8,816 (2012) 7,737 (2013)
Confidence Level	95%	95%	95%	95%
Confidence Interval	10	15	11.7	13.9
Sample size needed	95	43	70	40

A sample size for this research will be 70-40 professional SPE Members that need to be surveyed to get precise and reliable findings; based on the Confidence Level of 95% and SPE population of 12,778 - 7,737 PE Petroleum Engineers.

Justification of Smart PLS selection

A Partial Least Squares (PLS) is a method to structural equation modelling (SEM) that is broadly used to analyse quantitative data. Nevertheless, PLS has not been embraced in the project management discipline. Researcher considers using Smart PLS since it permits analysing of the measurement model concurrently with the structural model. This feature lets researchers tackle more complex research models with both moderating and mediating connections. Hence this research adopted Smart PLS as an analysis tool to analysis different lenses of complexity factors plus its connections and relationships to model the Oil & Gas projects in MENA region. The benefits of using Smart PLS will be the ability to compare and contrast analysis approach; moreover, the Smart PLS algorithm works to develop estimates for the measurement and structural models that further assist researchers in offering strategies to improve research models, data analysis, and the explanation of the results. These strategies offer further recommendations and policies that can be applied to manage projects in Oil & Gas sector (Nitzl, 2014).

3.3.7 Research Standard and Quality

Quality of research is about the characteristics of measurement tools, which should be efficient, easy to use, and accurate. So the validity, reliability, and practicality are the criteria for assessing measurement tools (Blumberg, et al, 2011). Meanwhile Zikmund et al (2011) stated that the three criteria for assessing measurement are reliability, validity, and sensitivity. Al-qurtas and Zairi, (2003) stating that the common measuring criteria for the quality and objectivity of research are reliability, external validity, and internal validity. Figure 4.4 show the quality and standard of research based on classification of Blumberg et al (2011) and Zikmund et al (2013).

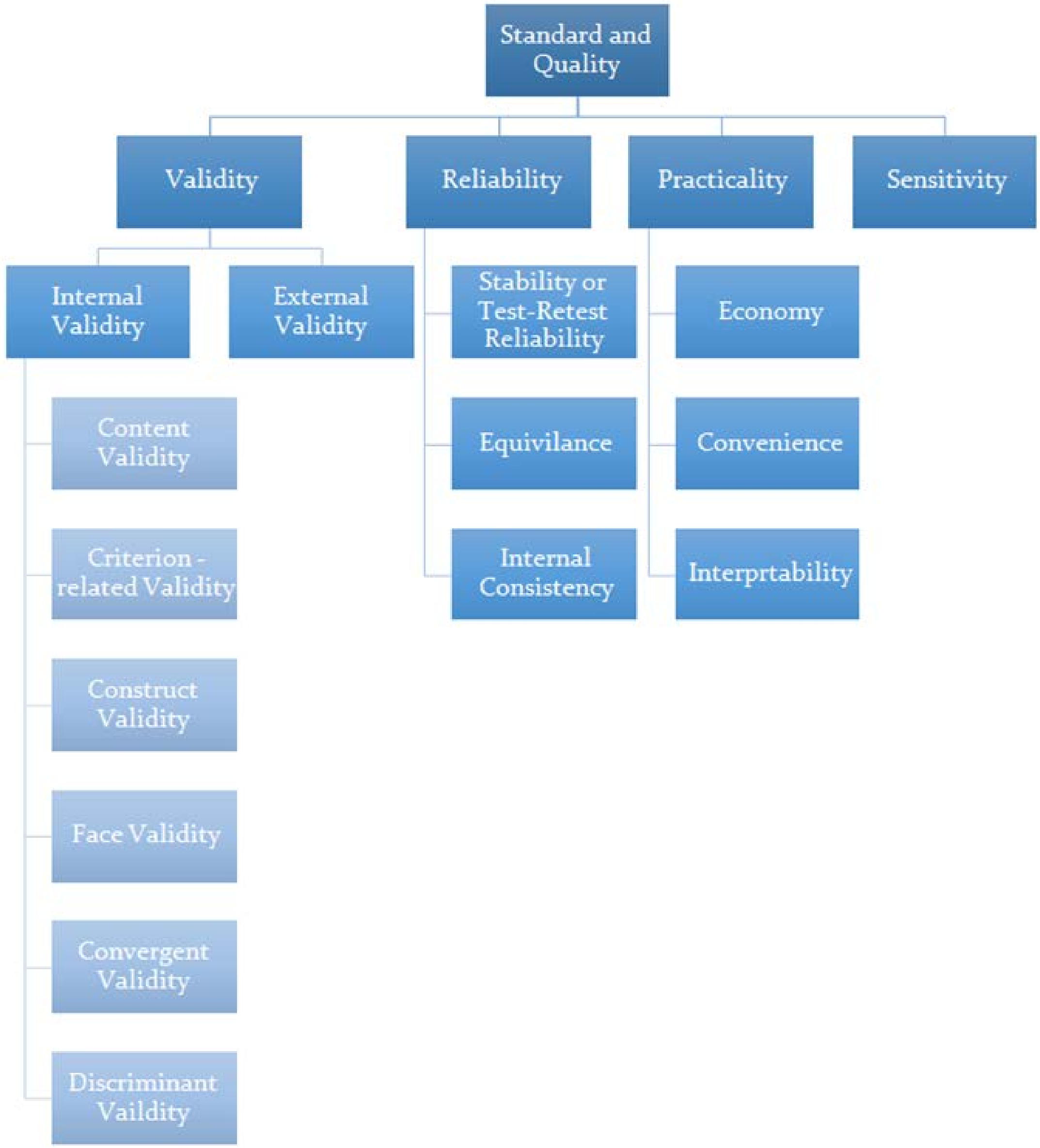


Figure 3-12 [Research Standards and Quality (Blumberg, et al, 2011; Zikmund, et al, 2013)]

Validity

Validity refers to the degree to which a test measures what the researcher actually wishes to measure, and to the degree to which differences found with a measuring instrument reflect true differences between participants being tested (Blumberg, et al, 2011).validity concerns with the degree to which the measure reflect the phenomena being observed (Wayhuni, 2012). The main major forms of validity are, internal validity and external validity, where external validity concern with research findings generalisation across settings, persons and time, meanwhile internal validity concern with the ability of research instrument to measure what is supposed to measure and another classification of validity forms are content validity, construct validity, and criterion-related validity (Blumberg, et al, 2011). Zikmund et al (2013) refer to classification of validity as face validity, content validity, construct validity, convergent validity, and discriminate validity.

Zikmund et al (2013) stated that Content validity is the extent to which that a measure covers the breadth of the domain of interest. Content validity is the range to which measuring instrument provide sufficient coverage of the investigative questions guiding the study. For assessing content validity of an instrument, must agree on the elements that shape sufficient coverage of the topic. Content validity determination is judgmental and can be accomplished by, researcher or designer who may determine it by careful definition of the concerned topic, scaling the items then applying the scale and another way by using a panel of people to judge the instrument in meeting the standards (Blumberg, et al, 2011). Whereas criterion-related validity is belonging to the success of measures employed for estimation or prediction, (Blumberg, et al, 2011). It is how does measure function in practice, and criterion validity could be classified as predictive validity or concurrent validity (Zikmund, et al, 2013).

Meanwhile, construct validity concerned with both measuring instrument employed and the theory, so after ensuring that the construct was meaningful in a theoretical sense, researcher then would investigate the adequacy of the instrument, so instrument measure the construct (Blumberg, et al, 2013). Whereas subjective agreement between professionals that the scale logically reflects the concept being measured, is the face validity. Convergent validity and discriminate validity concern about how measure distinct or unique. Therefore, discriminate validity refer to distinctiveness or uniqueness of a measure, indicating that measure in different construct, a scale must not correlate too high, but convergent validity indicates that concepts that related to one another are in fact related; high reliable scale contains convergent validity (Zikmund, et al, 2013).

Reliability

Reliability is concerned with the precision and accuracy of a measurement procedure and concerned with estimates of the extent to which a measurement is free of unstable or random error. So the reliability of the measure is to the extent that provides consistency results. Then reliable instrument is functioning well at different condition and different times (Blumberg, et al, 2011). A measure is reliable when different efforts at measuring something converge on the same result (Zikmond, et al, 2013). Reliability means the consistency of the measures, which facilitate the repeatability of the study (Wayhuni, 2012). Also, reliability is essential contributor to validity. Perspectives in reliability are stability, equivalence, and internal consistency (Blumberg, et al, 2011). Meanwhile, Zikmund et al (2013) refer to internal consistency and test-retest reliability. If the researcher can ensure consistent results with repeated measurement by the same person, using the same instrument is belonging to measure stability or test-retest reliability (Zikmund, et al, 2013; Blumberg, et al, 2011). Meanwhile, Equivalence is concerned with the difference at one point in time between observers and samples of items, and comparing their scoring of the same event is a suitable way to test the equivalence of the measurement (Blumberg, et al, 2011).

The third approach to reliability is internal consistency, which reflects to which extent instrument items are homogeneous and reflect the same underlying construct (Blumberg, et al, 2011; Zikmund, et al, 2013). It is an attempt to trustworthiness may need asking numerous similar but not identical questions, and the internal consistency of a multiple- item measures can be measured by correlating scores on subset of items shape a scale (Zikmund, et al, 2013). The Cronbach's coefficient alpha and Kuder-Richardson formula 20 (KR20) are two frequently used to measure reliability. But for multi-item scales, Cronbach's alpha has the most utility at interval level of measurement (Blumberg, et al, 2011).

Practicality

Practicality is an operational requirement defined as economy, convenience, and interpretability, economy related to the trade-off between budget and the ideal research; where instrument length must be taken in the consideration. And convenience is about the ease of instrument to be administered, and finally, interpretability, which is relevant when the interpretation is conducted by another person not the test designer (Blumberg, et al, 2011).

Sensitivity

Refer to the ability of instrument in measuring accurately the variability in a concept. So the sensitivity of the instrument could be increased by adding or increasing items to scale or by increasing response points, which giving greater range of possible scores (Zikmund, et al, 2013).

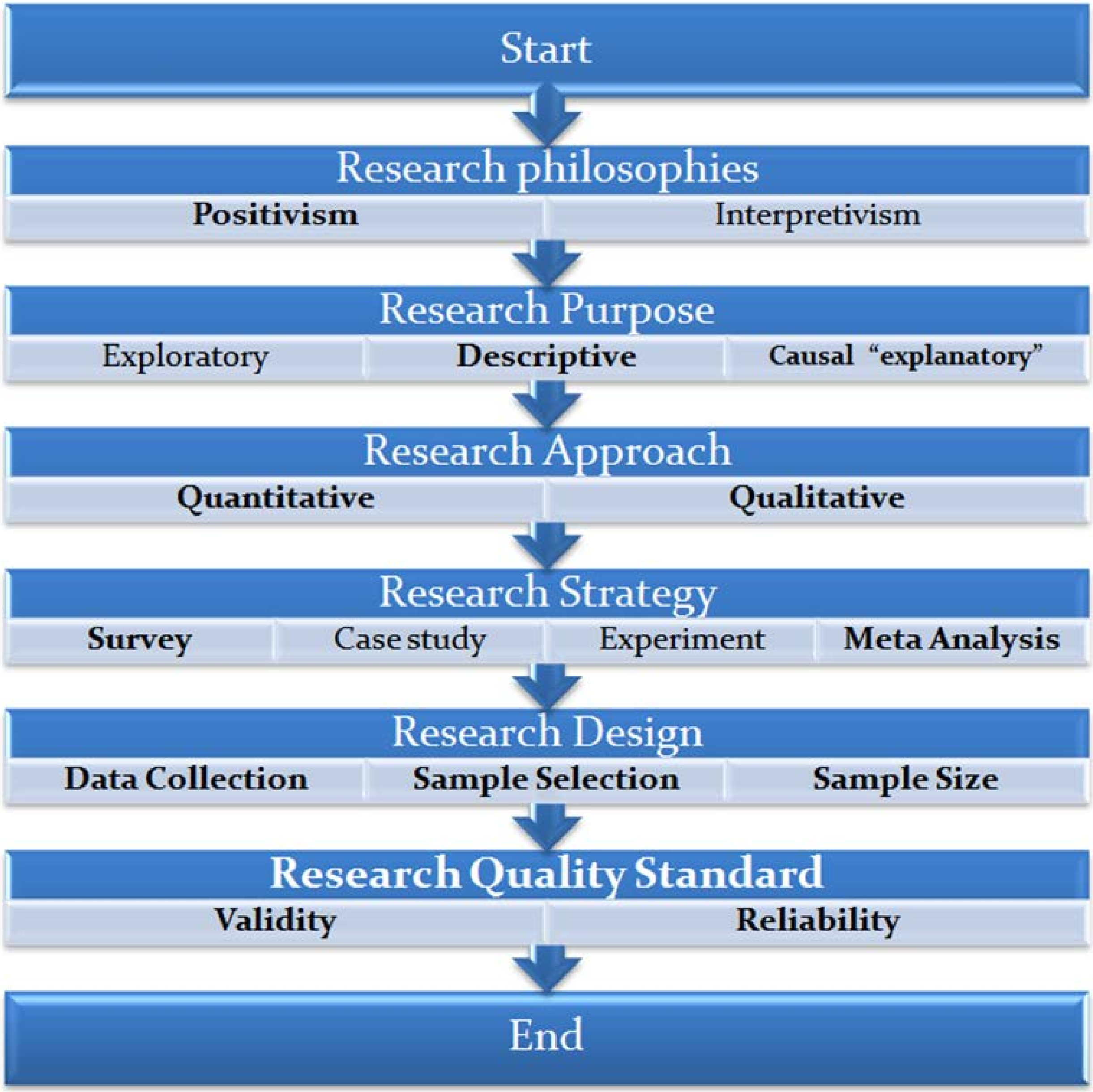


Figure 3-13 [Research Methodology Steps]

3.3.8 Summary

This chapter illustrates a clear view of a convenient methodology for solving the research problem. The chapter is structured as follows: the first section 3.3.1 provides an explanation the importance of the selection of the appropriate research philosophy. Then, Section 3.3.2 presents the Epistemology, Ontology, and Axiology assumptions, which form the basis of this research. In consequence, the chapter argues for the appropriateness of positivism, which emphasises the use of this method in this research. The reason for this decision is based on the aims, objectives and targeted problems of this research, as described in sections 1.2 and 1.3.

The chapter discusses the importance of adopting descriptive and explanatory research because the researcher will explain the relationship between variables related to project management and complexity theory to explain the findings by answering the research question. The justification for the selection of these purposes is given in section 3.3.3. The chapter justifies the use of Quantitative research that is dedicated to the study hypothesis, which must be proved or disproved in section 3.3.4.

The chapter discusses the research strategy defined as the survey in this thesis was given in section 3.3.5. The research design is presented in section 3.3.6, which includes data collection through questionnaire and interviews. A brief description of questionnaire's design stage is prepared which includes preliminary design and development of the survey form, and pilot test was done prior to distribution of the final version of the questionnaire as several drafts were prepared and amended in response to feedback received from responded. Also, based on our data collection methods, snowball sampling is the most suitable type when selecting research sample in this study. Finally, section 3.3.7 presents the research quality standards for this research, which include the reliability and validity.

3.4. Research Methodology for Meta-analysis

3.4.1. Introduction

Since 1970's systematic, quantitative techniques for integrating research findings across studies have been introduced in the research areas (Hunter, et al., 1982). Glass (1976) distinguished types of statistical analysis in the social sciences and coined the term "Meta-analysis" to refer to the analysis of analyses (Hedges and Olkin, 1985). Glass sought to distinguish Meta-analysis from primary analysis – the original analysis of data from a research study – and secondary analysis – the re-analysis of data to reaffirm answers to questions raised in the primary analysis, whereas other secondary analysis attempt to answer new research questions with better statistical techniques (Petitti, 2000).

This research presents a Meta-analysis review of primary studies for the comparison between different complexity factors on project management performance. Meta-analysis is a research approach in which results from many partially comparable empirical studies examining relationship or differences between similar variables, are systematically combined and integrated. It does not only describe the strength of the relationship or differences between two variables plus the direction either positive or negative association. The correlation among variables can be considered as effect size. The effect size is defined as '*the degree to which the phenomenon is present in the population or the degree to which the null hypothesis is false*' (Wolf, 1986). In Meta-analysis, the basic principle is to calculate the effect size for individual studies, convert them to a common metric, and then combine them in order to obtain an average effect size (Field and Gillett, 2010).

Glass (1976) identified three levels of analysis and thereby established a meaningful context for Meta-analysis statistical procedures. Firstly, Primary analysis refers to the original statistical analysis of data, as it is collected, by the researcher who collected the data. In other words, if a research conducted on the effects of X on Y, you might collect measurements of X and Y and calculate a correlation coefficient between these sets of measures; alternatively, you might calculate attest, compare the mean Y obtained under conditions of low X with the mean Y obtained under conditions of high X (Mullen 1989). These instances would constitute primary analyses. Secondly, Secondary analysis refers to the analysis of data by someone other than the researcher who collects the data, possibly for purposes, or with analytic strategies, other than those of the original researcher. Finally, Meta-analysis refers to the analysis of the results of several independent studies (Card, 2011).

In a traditional Meta-analysis, the true effects are considered homogeneous in the concerned studies, and then the outlier studies will be eliminated to fulfil this assumption. In other recent way or mixed model Meta-analysis' true effects are considered heterogeneous (different). Furthermore, the analysis offers an estimation of heterogeneity as a standard deviation to represent an unexplained typical true variation between studies, another characteristic in the analysis it may reduce heterogeneity, and provide details about the magnitude of the effect in different locations and with various subjects (Field and Gillett, 2010).

3.4.2. Justification of Meta-analysis selection

This section justifies the decision for employing Meta-analysis in the context of research undertaken. As reported in Section 5.1, Meta-analysis is a systematic quantitative review of original research studies of a phenomenon. In an attempt to better justify the decision for the use of Meta-analysis in this research, below is a summary of the main barriers to this research:

- Limited access to complex projects data: There are specific rules regarding the people that can access data in highly complex projects. If a way to retrieve some kind of data the information provided will not accurate to conduct this research.
- Different authors analyse complexity in a project using multiple methods and coming out with a wide range of results. These results are in many cases contradicting with the wide range of project management sectors, which cause additional confusion to the researchers.

Table 3-7 [Main barriers for Meta-analysis research]

Obstacles	Reason
Access Limitations	Access to accurate complex projects data was not feasible due to organisations regulations.
Data Accuracy	Data provided will not accurate and real.
Contradicting Views	Different researchers have different views regarding the same problem
Period	Data for long periods could not be collected
Confusion	Confusion exists due to the contradicting views of the different researchers

Overcoming the obstacles to this Research through meta-analysis can be done through the use of combining evidence across studies. Since meta-analysis typically relies on data in the form of summary statistics derived from the primary analyses of studies, it is truly an analysis of the result of statistical analyses. This means that meta-analysis is the quantitative cumulative and analysis of descriptive statistics across studies. As a result, it does not require access to the original study data (Petitti, 2000).

The comprehensive investigation of complexity in project management requires the combination of results from several individual studies. More casual factors of a particular effect are likely to be detected by a research synthesis than by single study. Often different individual study provides conflicting results which can have confusing implications (Wolf, 1986). This means that past research finding on the subject under research are problematic. Meta-analysis is adopted as a research method to synthesize the past research findings. Among different methods that maybe used to synthesize the literature, then meta-analysis is theoretical will be more flexible (Hedges and Olkin, 1985).

Robinson (2014) emphasized that the meta-analysis can face a number of barriers such as access to respective information; the measures required validating the accuracy of the data and biased opinions that may deflect the research in the different direction.

Mertens (2014) stated that all these barriers could affect the regulations of the result, which compromise the conduct of research in a respective manner. The projects could lead to complicated direction with respect to obtaining respective information. The analysis process is comprehensive which demands the evaluation of data from the different direction, which in this case involves the attributes of the different range of project management factors. This may delay the process and may create confusion in every direction.

3.4.3. Stages of Meta-analysis Process

There are four stages in a Meta-analysis. Firstly, studies with relevant data are identified. Secondly, eligibility criteria for inclusion and exclusion of the studies are defined. Thirdly, data are extracted. Fourthly, the extracted data is analysed statistically. This analysis includes formal statistical tests of heterogeneity and exploration of the reasons for heterogeneity (Petitti, 2000). However, researchers should adopt in advance a detailed research protocol that clearly states the objectives, the assumption or hypothesis to be tested, the subgroups of interest, and the proposed methods and criteria for identifying and selecting relevant studies and extracting analysing information (Card, 2011).

3.4.3.1. Identifying Studies for the Meta-analysis

During the first stage, the researcher decides what distinguishes between relevant and irrelevant material. The variables under inquiry need to be defined properly and to be provided explanations (Cooper, 1998). A critical feature of the proper application of the method of Meta-analysis is the development of systematic, explicit procedures for categorizing studies with related data. The systematic, explicit nature of the procedures for study identification distinguishes Meta-analysis from the qualitative literature review. In being systematic, the procedure reduces bias. In being explicit, the procedures help to ensure reproducibility (Petitti, 2000).

Identification of published studies usually begins with a search of personal reference file and it is followed by a computerised search of literature database. Reference lists of review articles are also reviewed to check for completeness of the assembled list of relevant publications. It encompasses major journals, conference proceedings, books and dissertations. The studies that best fit the research questions are included in the Meta-analysis (Card, 2011).

3.4.3.2. Eligibility Criteria for Including and Excluding Studies

After studies with relevant information have been identified, the next stage in the Meta-analysis is to define eligibility criteria for the Meta-analysis. Not all studies can or should be included in the meta-analysis. The studies that do not meet the criteria related to the research questions or assumptions are always eliminated. The goals of defining eligibility criteria are to ensure reproducibility of the Meta-analysis and to minimise bias in the selection of studies for the meta-analysis. The studies chosen for the Meta-analysis should be unbiased with respect to their results and their conclusions (Petitti, 2000).

3.4.3.3. Collecting Data from Investigators

In a Meta-analysis, there are usually two levels of data abstraction. First, data that document whether or not identified studies are eligible for the Meta-analysis study need to be abstracted for all of the studies identified. Next, for all qualified studies, data on the related results of the study are abstracted. Data must be summarized into structured forms that have been pre-tested, and explicit plan to ensure the reliability of abstraction should be in place. The explanation of the data collection will be discussed in more details in chapter 4.

3.4.3.4. Analysing the Data

The last stage in a Meta-analysis is to analyse the data. Analysing properly includes a test of homogeneity of the effect size. If the results are homogeneous, a summary estimate of effect size can be appropriately estimated. The Meta-analysis should also explore heterogeneity. The exploration of heterogeneity should attempt to determine whether there are features of the studies or the study population that are related to effect size. Exploration of heterogeneity also includes an examination of a subgroup result in the aggregation of studies. When it is appropriate to present a summary estimate of effect size, this estimate should include a major of its variance and its 95 %

confidence interval. The analysis of the data using Meta-analysis will be discussed in more details in chapter-4.

3.4.4. Meta-analysis Limitations

Meta-analysis as a technique is still being developed and some matters concerning use remain unsettled. The analysis is not free from criticisms. They are prone to over generalise, include results from poorly designed studies, biased to published research over unpublished research; give more weight to studies with multiple results and ignore studies from the effect size cannot be computed. The issues are receiving the most attention of present concern the "file-drawer" problem and the calculation of effect size. The use of Meta-analysis to perform research syntheses that include cost remains unaddressed and undetermined. The file drawer problem may still from the reluctance of professional journal editors to include studies whose result failed to reach statistical significance and the reluctance of researchers to report their null results. These studies remain in the file drawers of the researchers (Rothstein et al, 2005).

3.4.5. Research Design

The first step in the research design is to review the literature. In Chapter 2 the researcher presented a wide range of literature review on the complexity factors and their effect on project management performance and identified research issues for further investigation. In doing so, the researcher highlights some limitations of the literature dealing with complexity in project management environment. (a) The need of theoretical model and research regarding copying of complexity within project management processes (b) The relationship between complexity and project management and its impact on projects performance (c) The motivation of project managers to use modern tools/models for complex projects. (d) The investigation of how the complexity contributes towards the development of project management outcomes.

Meta- analysis will be used to study the correlation between the complexity factors under focus in order to understand the common complexity factors within research under investigation. The researcher proposed the following five assumptions groups to further investigate these issues:

Group A: Technical category

1) **A1**: Non-alignment of project goals has a significant impact on increasing project complexity.
2) **A2:** Clarity of goals has a significant impact on increasing project complexity.
3) **A3**: Project Team competency "Technical perspective" has a significant impact on increasing project complexity.
4) **A4:** Technical complexity has a significant impact on increasing project complexity.

Group B: Organisational category

1) **B1**: Financial risks have a significant impact on increasing project complexity.
2) **B2**: Project leadership has a significant impact on increasing project complexity.
3) **B3:** Projects management complexity has a significant impact on increasing project complexity.

Group C: Project Environment category

1) **C1**: Safety of environment (Region, country, or city) has a significant impact on increasing project complexity.
2) **C2**: Political Stability of environment (Region, country, or city) has a significant impact on increasing project complexity.
3) **C3**: Instability of Oil Prices has a significant impact on increasing project complexity.

Group D: Health, Safety, & Environment (HSE)

1) **D1**: Operational risks' affecting processes and people has a significant impact on increasing project complexity.
2) **D2**: Corporate environmental responsibilities have a significant impact on increasing project complexity.

3) **D3**: Project location safety and security concerns have a significant impact on increasing project complexity.

Group E: Project Management in Complexity

1) **E1**: Dependencies between tasks has a significant impact on increasing project complexity.
2) **E2**: Interdependency between used Technologies has a significant impact on increasing project complexity.
3) **E3**: Compatibility of different pm methods and tools has a significant impact on increasing project complexity.
4) **E4**: Interfaces between different disciplines have a significant impact on increasing project complexity.
5) **E5**: Number of different cultures has a significant impact on increasing project complexity.
6) **E6**: Interdependence with other projects within organisation has a significant impact on increasing project complexity.
7) **E7**: Communication within project teams and stakeholders has a significant impact on increasing project complexity.
8) **E8**: Project Environment change has a significant impact on increasing project complexity.
9) **E9**: Interaction with governments and regulatory bodies has a significant impact on increasing project complexity.

10) **E10**: Media influence has a significant impact on increasing project complexity.

These assumptions have been used by the researcher to develop a conceptual model. The proposed conceptual model makes a novel contribution since (a) it includes a number of consistent influential factors for the project's complexity; (b) it can be used as a frame of reference for the comparison in different categories. The model proposes that five dimensions namely.

After the development of the conceptual model, the selection and justification of an appropriate research methodology are taking place. For the purpose of this research as explained in Section 3.2, Meta-analysis was selected to contact this part of research. This leads to next stage, which is to, identifying the moderator variables, and formation pre-understanding and initial theoretical offering as illustrated in Figure 5.1. Thereafter, the establishing criteria for including and excluding are conducted to develop a research protocol. Based on the needs to collect the data, it was decided that the research design would utilise a vote counting and "d" effect size strategy through the employment of Meta-analysis research methods. These are explained in more details in the following sections.

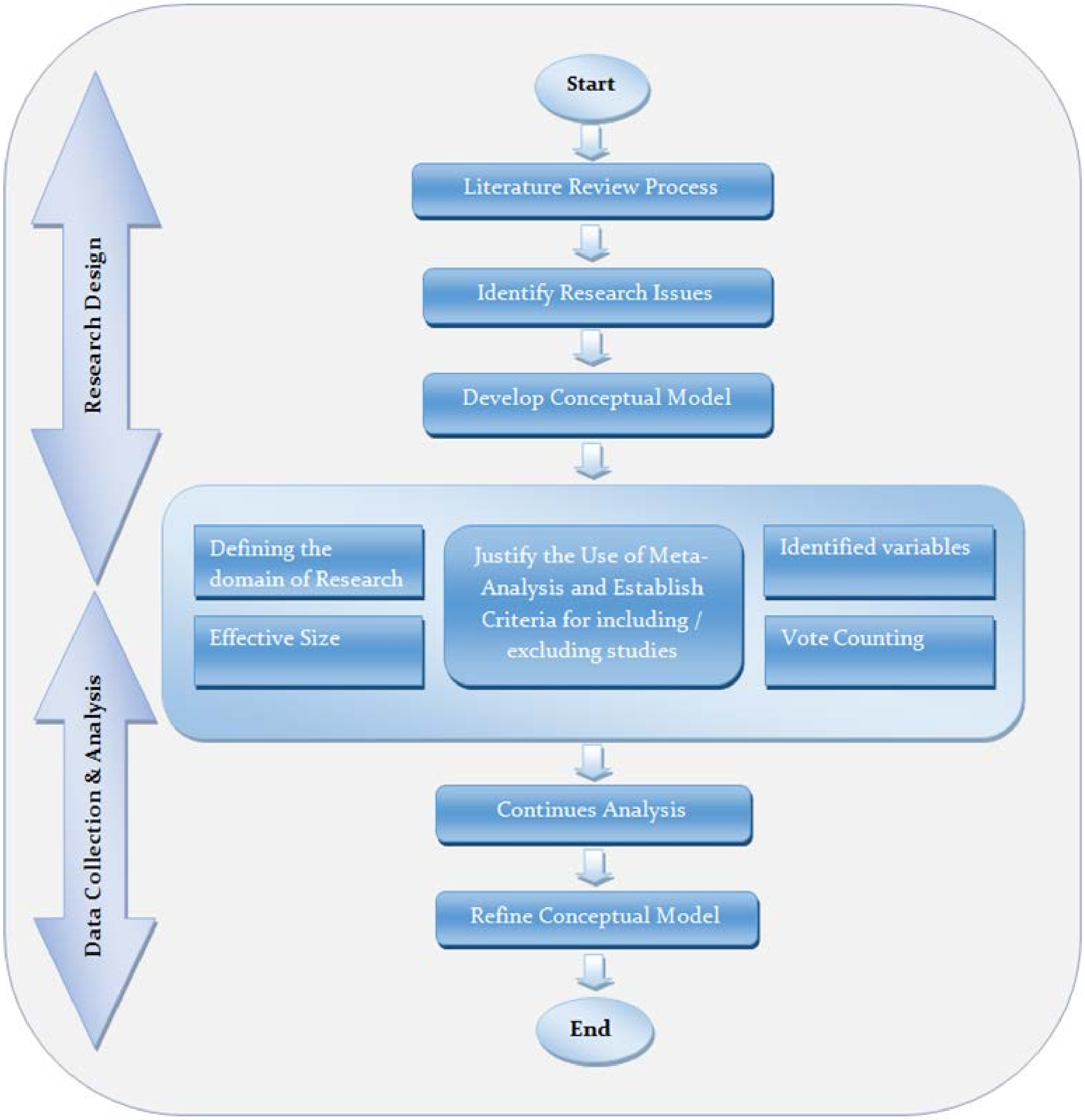


Figure 3-14 [Empirical Research Methodology for Meta-analysis]

3.4.5.1. Defining the Domain of Research

The first step in planning the study is to define the problem. The problem definition is a general statement of the main questions that the study addresses. Usually, this occurs when a researcher uses categories of independent variables that are excessively broad. Confirmed in a different way, this happens when a researcher does not adequately specify the domain of research. This involves identifying the primary independent variables as well as modifying or moderating variables.

In this study, the overall domain of interest is to investigate and compare different projects complexity factors and how each one influence project performance. Additionally, a suggestion will be made -according to the result- about the correlation between the two complexity factors.

As discussed in Chapter 2, a number of researchers have previously been conducted studies on the project management complexity that addresses factors affected project performance. To improve on the previous efforts, this study utilised a theory that assumes the interaction of five elements, which are Technical, Organisational, Project Environment, Health, Safety, & Environment (HSE) and Project Management in Complexity. The five elements create a highly specific categorisation system for the research on projects complexity.

3.4.5.2. Identifying the Moderator Variables (Methodological classification)

The purpose of Meta-analysis is to arrive at the reasonable summary of the quantitative finding in the previous research and not simply to average the findings. In case, the effect sizes are found to be non-homogenous then search for moderator variables is suggested (Lipsey and Wilson, 2001). Hunter and Schmidt (1990) say that no study can be without methodological inadequacy. They suggested for testing the moderator variables if one observes substantial variations across studies and are solely not due to artifacts. The factors that might cause variation in magnitude of the relationship between two variables are known as moderator variables (Rosenthal, 1991). Sharma, et al., (1981 p.291) defined a moderator variable as "one which systematically modifies either the form or strength of the relationship between the predictor and a criterion variable".

Some studies used in this meta-analysis provided an evaluation of the methodological classification of the study or studies they included. The vast majority of those studies are classified into three categories: (a) significant difference, (b) non-significant difference, (c) partial significant. The classification for these studies was simply incorporated into this effort. For studies where methodological quality was not a control factor, the system employed by Cohen (1969), Glass, and Miller (1980) was used to code methodological classification. In this research, two categories were used to code this moderator variable: published studies and unpublished studies. Published studies were defined as those that appear in journals and books. Unpublished studies were defined as those appearing in dissertations, conference papers, or technical reports.

This moderator variable dealt with the type of publication in which a study was reported. It is generally assumed that publications in highly competitive, refereed venues will report larger effect sizes than publications in less rigorous and less competitive venues. The reason for this assumption is that studies reported in more competitive and rigorous venues will control better for extraneous variables and, therefore, produce less inflated effect sizes. Durlak (1995) explains that this artifact is commonly referred to as publication bias that is related to the 'file drawer problem'. Publication bias is related to the so-called 'file drawer problem' which is the tendency for researcher not to submit the study or journals not accepting to publish studies that fail to achieve statistically significant results (Rosenthal, 1979). As a result, experiments that do not turn out as expected fade away in investigators file drawers, whereas the published literature contains a preponderance of positive findings (Durlak, 1995).

3.4.5.3. Establishing Criteria for Inclusion in the Study

The selection of studies to be included in a meta-analysis is commonly cited as one of the most critical design variables. As Durlak (1995) notes: "The ultimate goal of a literature research is to obtain a representative and nonbiased sample of relevant investigations". Commonly, three major techniques are employed to locate relevant studies: (a) computer searches, (b) manual searches, and (c) examinations of reference lists in identified studies. Computer searches usually employ one or more of the following databases: Journals, Conference Papers, Dissertation Abstracts, and Governmental Reports. After computer searches have been completed, researchers will commonly hand-search specific journals that are particularly related to the topic.

Finally, when studies are found that cite other studies whose titles appear to be particularly relevant, these secondary sources are also retrieved. Because of the breadth of this meta-analysis, a somewhat different search protocol was employed from that described above. The criteria for including studies in the review were as follows:

- The time period covered in the review: 1996–2015.
- Published/ unpublished studies: Both types were included.
- The quality of a study: Only studies showing no severe methodological flaws were included.
- Control group: Each primary study had a control or comparison group.
- Sufficient quantitative data: The results of these studies all provided sufficient quantitative data from which effect sizes were calculated.

Three variables should be taken into consideration when establishing criteria for inclusion in the study, which are: (a) precision, (b) objectivity, and (c) replicability.

Precision: A properly conducted meta-analysis is nothing if it is not precise. The specific strategies and techniques for taking the statistical results of independent studies, converting these results to a few common statistical metrics, and then combining, integrating, and testing these statistical results are wholly designed to be rigorously precise. Alternatively, a traditional narrative review by definition does not have any precise method or strategy for abstracting the evidence from each study. A narrative review is ill-equipped to take into account the interrelations between significance level, sample size, and effect size, in the manner of a carefully conducted meta-analysis. This is reflected in the level of precision of the conclusions derived from the two approaches to summarizing research.

Objectivity: The rules and standards for including studies in the review process, abstracting results from them, and weighing them in the final integration are never made explicit in a traditional narrative review. In contrast, these rules and standards must be made explicit in any meta-analytic review. The rules and strategies that are followed in a meta-analysis for including, abstracting, weighting, and integrating studies are generally more objective. Even where some subjective judgments may have to be made in conducting a meta-analysis, these subjective judgments are made public, articulated, and submitted to careful scrutiny by the reviewers and audience of the meta-analysis. For example, one might argue that the decisions as to which studies should be included in the review of a particular research domain are a subjective decision on the part of either type of reviewer. However, this decision is likely to remain implicit and inarticulate in the case of a traditional narrative review, whereas it must be made explicit and public in the case of a meta-analytic review.

Replicability: One product of the objective and public nature of the rules and strategies that guide a meta-analysis is a high degree of replicability. In other words, the conclusions derived from a metanalytic review of a given research domain are the same conclusions at which anyone would have arrived if they had included the same studies and followed the same rules for integrating study outcomes. On the other hand, because the rules and strategies of the traditional narrative review are not objective and public, the same research domain can be reviewed by two different narrative reviewers and give rise to two very different conclusions.

3.4.5.4. Determining the Types of Effect Size

Different statistical methods exist for combining the data, but there is no single correct method. Two popular approaches are those of Glass (of which the basic formula for 'd' is 'the Mean of control group minus the Mean of treatment group, divided by the Standard deviation of the control group' (Glass et al., 1981); and Hunter and Schmidt (1990) who suggested a "pooled within-group standard deviation" and correcting the effect size for measurement error. In order to accomplish a Meta-analysis, the results of each study have to be explained in a common metric, capable of representing the relationship between two variables. With this aim, an index of the effect magnitude is defined to represent the overall result of each study.

The difference in effect size estimators is the denominator used to scale the difference between the mean of the experimental and control groups. Glass's delta utilises the standard deviation of the control group, Cohen's "d" utilises the standard deviation of the population, and Hedges' "g" utilises the pooled standard deviation from the experimental and control groups. When the population standard deviation was available, Cohen's "d" was utilised. Such would be the case when a standardised dependent measure was used and the population variance or standard deviation could be obtained from that measure. The researcher will utilise Cohen's "d" as a measure of effect size between the mean of experimental and control groups in this research. In a number of cases, means and standard deviation were not available. In these situations, effect sizes were estimated using conversion formulas.

3.4.6. Vote Counting as a Method

After examining the distribution of effect sizes, it is common for Meta-analysis to count the number of positive and negative findings that occur in the data set that statistics it was not possible to be count. Vote counting procedures were in use by reviewers to quantify summary statistics before the advanced Meta-analysis methodology was introduced. The choice of research methods influences the way in which the researcher collects data. Specific research methods also imply different skills, assumptions and research practices. According to Galliers (1992), all research is based on some underlying assumptions about what constitute "valid" research and which research methods are appropriate. In order to conduct and/or evaluate research, it is therefore important to know what these assumptions are.

Narrative reviews are literature reviews that attempt to make sense of past findings verbally or conceptually. Traditional narrative reviews are often inclusive, especially when the review includes several individual findings supporting conflicting hypotheses.

The vote counting method refers to the accumulation of significance level or, in the simple case, to the tabulation of three findings categories: (a) those with statistically significant results in one direction (Positive), (b) those with statistically significant result in the opposite direction (Negative) and, (c) those with statistically insignificant results (Non-significant) (Hunter and Schmidet, 1990). The meta-analyst then would declare that the category with the largest number of findings should represent the literature as a whole. The vote count of significant findings is unacceptably conservative. The problem is that chance alone should produce only about 5% of all comparisons falsely indicating a treatment has a positive effect, whereas this strategy requires that more than 33% of findings be positive and statistically significant before a treatment is ruled effective. Thus, the vote count of significant findings could, and often does, lead to the suggested abandonment of treatments when, in fact, no such conclusion is warranted.

A different way to perform vote counts in research synthesis involves counting the number of positive and negative results, regardless of significance. This method has the advantage of using all findings, but it suffers because the impact of the treatment under evaluation in each comparison is not considered, for example; a comparison showing a large positive change is given equal weight to one showing a small negative change.

These methods tend to give equal weight to studies with different sample size and effect at varying significance levels, resulting in misleading conclusions. In fact, the statistical errors in the typical "vote counting" literature review tend to be more serious than in the average narrative review because the statistical power of the vote counting procedures decreases with increasing number of studies reviewed. Therefore a major problem will be to define the effect size plus failure to categorise the variables (Hunter, Schmidt and Jackson 1980). Meta-analyses have advantages over the traditional review. It demonstrates the direction of the effect and recognises the moderator variables. This will include the quantitative studies related to the research question eliminating subjectivity introduced by selective sampling. Meta-analysis can offer an overall decisive answer to the research question (Glass, McGaw and Smith, 1981).

3.4.7. Summary

The aim of this chapter is to examine and describe the Meta-analysis research methodology namely that applied for the research described in this dissertation. Based on the area of this research, Meta-analysis would give the broadest view of the problem domain. In providing a detailed consideration of the issues related to the practical search for knowledge, the chapter began by providing an exposition of the different philosophical foundations of information systems research. The reason for this decision is based on the aim of this part of research as described in Section 3.4.5.

Based on a deep exploration on researches and papers in the subject, no systematic empirical research exist, conducted using Meta-analysis of the literature on complexity on project management. Specifically, that looks at all available studies from all available sources. Researcher expectation that Meta-analysis will provide a thorough, organised, clearly defined, and broadly investigated analysis of the literature on complexity factors/ sources in projects management.

4. Data Analysis and results

4.1. Introduction

The data analysis chapter contains three stages; first organising the data for analysis, then utilises a descriptive statistics in order to outline the information extracted from raw data. Finally, researcher will test hypotheses and model aiming to validate results. In this phase, the questionnaire that was developed according to research objectives was distributed among the chosen sample. Which was involved an engineering society working in project management environment and data collection will be based on snowball sampling. Moreover, researcher conducted a detailed interview of people with a solid understanding of executing projects in complexity and a clear view of various factors that contribute towards project complexity and how this could affect project performance.

Furthermore, Meta-analysis, a statistical technique combines and contrasts the findings of independent studies in the project complexity field. It intends to cover all the related and independent studies, look for the presence of heterogeneity, identify patterns and aims to achieve robust conclusions by using sensitivity analysis. Quality effects models can facilitate the outcome by giving weight to higher quality research completed in the Projects complexity (Cooper et al., 2009).

4.2. Descriptive Analysis

The descriptive analysis describes the main characteristics of a collection of data through providing simple summaries about the sample the personal information that were calculated are:

- What's your age?
- Work years of experience,
- What is your gender?
- Do you have formal Project Management training? And Nature of projects (NOP).

In the following sub-section, the frequency of each option with its percent will be described.

4.2.1. The Sample Description According to: what's your age

Table 4.2-1 [Respondents age groups]

what's your age	Frequency	Percent
18-24	0	0%
25-34	13	24.1%
35-44	19	35.2%
45-54	10	18.5%
55-64	11	20.4%
65-74	1	1.9%
75 and older	0	0%
Total	54	

Table (4.2.1) describes the research sample through the respondents Age. The respondent Age category was divided into seven groups. The largest group consists of 35.2% respondents with an age range between (35-44years). The smallest group consists of 0% respondents with an age range is (75 and older) and (18-24 years).

This indicates that the largest numbers of posts within the managerial level of the oil and gas in MENA region are young.

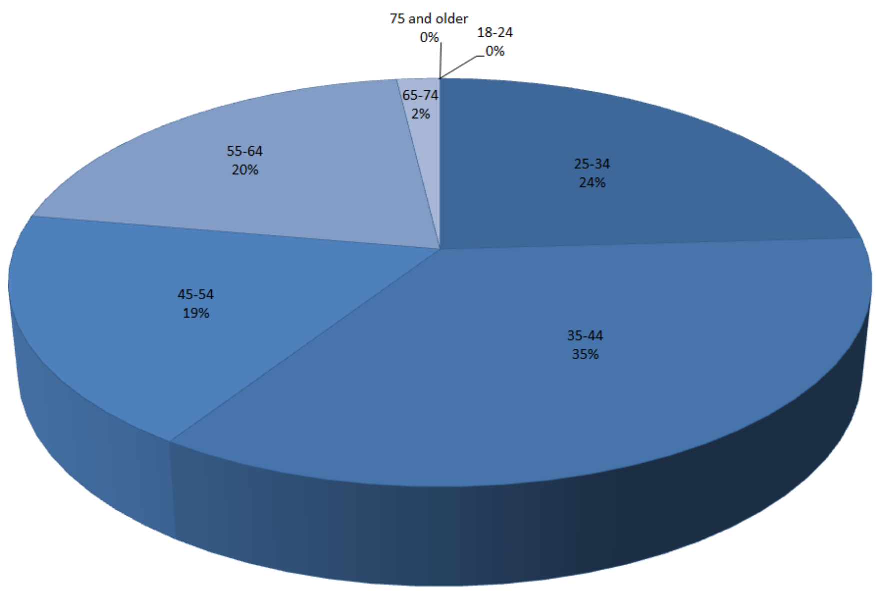


Figure 4-1 [Respondents age groups]

4.2.2. The Sample Description According to Work years of experience

Table 4.2-2 [Respondents: Work years of experience]

Respondents' Work years of experience	Frequency	Percent
3-10	20	37.0%
11-19	12	22.2%
20-28	8	14.8%
29-37	10	18.5%
38-46	4	7.4%
other	0	0%
Total	**54**	

Table (4.2.2) describes the research sample through the years of experience of respondents. The respondent's years of experience category was divided into four groups. The largest group consists of 37% of respondents with years of experience range between (3-10 years). The second largest group consists of 22.2% of respondents with years of experience range between (11-19 years). The third group consists of 14.8% of respondents with years of experience range between (20-28 years). The fourth group consists of 18.5% of respondents with years of experience range between (29-37 years). This confirms that the majority people in the managerial level of the oil and gas organisations in MENA region have good experience in the oil and gas industry field. The approximately percentage of employees experience over 10 years is 63%.

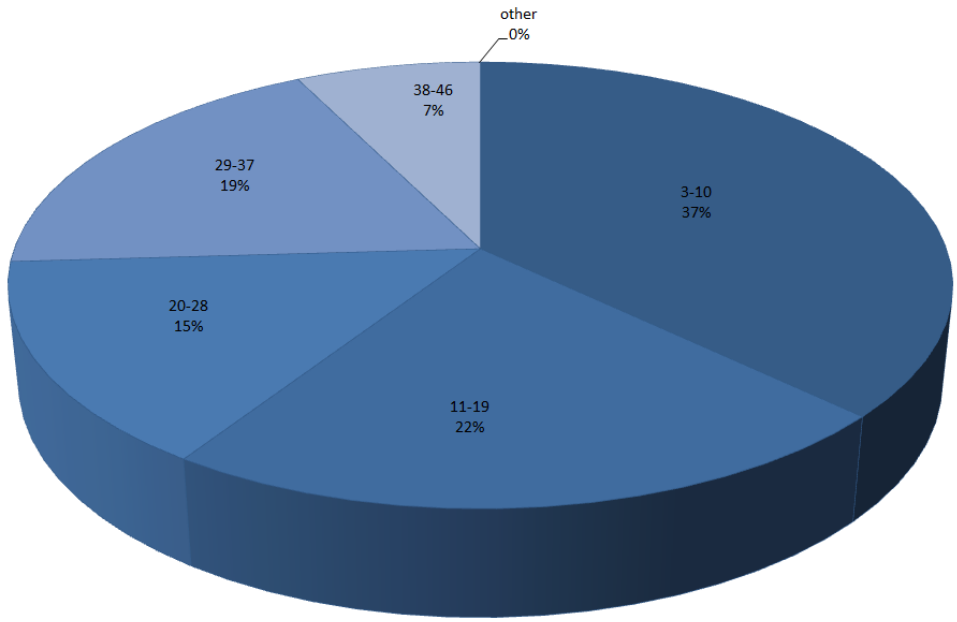


Figure 4-2 [Respondents' Work years of experience]

4.2.3. The Sample Description According to what is your gender

Table 4.2-3 [Respondents gender]

What is your gender	Frequency	Percent
male	51	94.4%
female	3	5.6%
Total	54	100%

Table (4.2.3) describes the research sample through the respondents ' Gender. The sample of research contains 54 respondents; 51 males with a percentage of 94.4% and 3 females with a percentage of 5.6%. This indicates that the largest number of posts within the managerial level of the oil and gas organisations in MENA region is male sex.

4.2.4. The Sample Description According to the formal Project Management training

Table 4.2-4 [Respondents formal Project Management training]

Do you have formal Project Management training	Frequency	Percent
yes	20	37.0%
no	34	63.0%
Total	54	100%

Table (4.2.4) describes the research sample through formal Project Management training. The sample of research contains 54 respondents; 34 didn't take formal project management training with a percentage of 63% and 20 who did take formal project management training with a percentage of 37%. This indicates that the most of the managerial level of the oil and gas organisations in MENA region didn't adopt project management methods and training for handling projects in the industry. This was clearly noticed by the researcher while discussion through surveys and interviews with industry, furthermore project management methods if implement was really shallow and only starch in the wall compared to other industries such as civil engineering, IT, and telecommunications. Hence most members were looking to complexity and all its aspects as factors that will lead to projects failure and negatively affect project performance. This understating was based on the understanding of complexity as an opposite to simple and easy.

4.2.5. The Sample Description According to Nature of projects (NOP)

Table 4.2-5 [Respondents nature of projects (NOP)]

Nature of projects (NOP).	Level	Frequency	Percent
Stability of the overall projects context	Low	9	16.7%
	moderate	36	66.7%
	high	9	16.7%
Number of different disciplines, methods or approaches involved in performing the projects?	Low	3	5.6%
	moderate	29	53.7%
	high	22	40.7%
Magnitude of legal, social, or environmental implications from performing the projects?	Low	8	14.8%
	moderate	29	53.7%
	high	17	31.5%
Overall expected financial impact (positive or negative) on the project's stakeholders?	Low	5	9.3%
	moderate	20	37.0%
	high	29	53.7%

Strategic importance of the projects to the organisation or organisations involved?	Low	3	5.6%
	moderate	20	37.0%
	high	31	57.4%
Stakeholder cohesion regarding the characteristics of the product of the project?	Low	4	7.4%
	moderate	38	70.4%
	high	12	22.2%
Level of complexity in the project	Low	1	1.9%
	moderate	16	29.6%
	high	37	68.5%
Total		54	

Table (4.2.5) describes the research sample through the respondent's Nature of Projects. The sample of research contains 54 respondents; 91% believe they are dealing with moderate and high complexity in projects. Furthermore, 42% handled high complexity level in assigned projects. Yet when asked directly about the level of complexity in their assigned projects 68.5% respondent's answered it high. This indicates that the largest numbers of posts within the managerial level of the oil and gas organisations in MENA region are not familiar with complexity factors and nature of the reflection in managing projects in complexity. Based on such observation researcher starts to give an introduction about projects management and complexity science, hence debate factors of complexity and ways those factors could manage projects in complexity. The researcher kept in mind not to cause a bias on the respondent's view of complexity factors and managing projects in complexity, just showing the description Nature of projects in complexity lens.

4.3. Means and Standard Deviations

The description of the research respondents aims to identify the answers of respondents in the project management in oil and gas in MENA region according to Likert scale. In the following sub-section, the tables show the means and standard deviations (SD) for the research dimension.

4.3.1. Means and Standard Deviations of Technical Category

Table 4.3-6 [Means and standard deviations for each item in the Technical Category]

Items	Mean	SD
Goal alignment	4.3704	0.89646
Clarity of goals	4.4630	0.90518
Quality requirements	4.1852	1.13394
Project Team competency "Technical prospective"	4.2778	1.05360
Technical complexity	4.3333	1.16554
Total	4.314825	

Table (4.3.6) indicates that there is an influence of Technical Category by the organisations surveyed. There is some kind of reflections by the management level in the oil and gas in MENA. The result of the means for the respondent's responses average ranged between (4.1852) and (4.3704), it reflects the level of approval on the content of statements made by individual respondents.

The standard deviation of the responses reflects the low degree of dispersion, while the standard deviation ranges between (0.89646) and (1.16554), this shows the consistency in the responses response that supports the assurance of the importance of Technical aspect of complexity.

The researcher believes that this result was consistent with the orientations of Oil and Gas organisations in MENA concern about the projects.

4.3.2. Means and Standard Deviations of Organisational Category

Table 4.3-7 [Means and standard deviations for each item in the Organisational Category]

Items	Mean	SD
Financial risks	4.2407	1.09777
Project leadership	4.4444	0.83929
Projects management complexity	4.2778	1.17227
Total	4.320967	

Table (4.3.7) indicates that there is an influence of Organisational Category by the organisations surveyed. There is some kind of reflections by the management level in the oil and gas in MENA. The result of the means for the respondent's responses average ranged between (4.2407) and (4.4444), it reflects the level of agreement on the content of Organisational Category.

The standard deviation of the responses reflects the low degree of dispersion, while the standard deviation ranges between (0.83929) and (1.17227); this shows the consistency in the responses response that supports the assurance of the importance of the Organisational aspect of complexity in oil and gas projects in MENA region.

The researcher believes that this result was consistent with the orientations of Oil and Gas organisations in MENA concern about the projects.

4.3.3. Means and Standard Deviations of Project Environment Category

Table 4.3-8 [Means and standard deviations for each item in the Project Environment Category]

Items	Mean	SD
Safety of environment (Region, country, or city)	4.1481	1.13947
Political Stability of environment (Region, country, or city)	4.2222	1.07575
Instability of Oil Prices	4.3333	1.06399
Total	4.234533	

Table (4.3.8) indicates that there is an influence of Project Environment Category by the organisations surveyed. There is some kind of reflections by the management level in the oil and gas in MENA. The result of the means for the respondent's responses average ranged between (4.1481) and (4.3333), it reflects the level of agreement on the content of Project Environment Category.

The standard deviation of the responses reflects the low degree of dispersion, while the standard deviation ranges between (1.06399) and (1.13947); this shows the consistency in the responses response that supports the assurance of the importance of Project Environment aspect of complexity in oil and gas projects in MENA region.

The researcher believes that this result was consistent with the orientations of Oil and Gas organisations in MENA concern about the projects.

4.3.4. Means and Standard Deviations of Health, Safety, and Environment (HSE) Category

Table 4.3-9 [Means and standard deviations for each item in the Health, Safety, & Environment (HSE) Category]

Items	Mean	SD
Operational risks affecting processes and people	4.0185	1.26626
Corporate environmental responsibilities	3.9630	1.19690
Project location safety and security concerns	4.0000	1.13270
Total	3.993833	

Table (4.3.9) indicates that there is an influence of the Health, Safety, & Environment (HSE) Category by the organisations surveyed. There is some kind of reflections by the management level in the oil and gas in MENA. The result of the means for the respondent's responses average ranged between (3.9630) and (4.0185), it reflects the level of agreement on the content of the Health, Safety, & Environment (HSE) Category.

The standard deviation of the responses reflects the low degree of dispersion, while the standard deviation ranges between (1.13270) and (1.26626); this shows the consistency in the responses response that supports the assurance of the importance of the Health, Safety, & Environment (HSE) aspect of complexity in oil and gas projects in MENA region.

The researcher believes that this result was consistent with the orientations of Oil and Gas organisations in MENA concern about the projects.

4.3.5. Means and Standard Deviations of Project Management in Complexity Category

Table 4.3-10 [Means and standard deviations for each item in the Project Management in Complexity Category]

Items	Mean	SD
Dependencies between tasks	3.9630	1.06333
Interdependency between used Technologies	4.0185	1.15727
Compatibility of different pm methods and tools	3.8148	1.15046
Interfaces between different disciplines	3.7222	1.20403
Number of different cultures	3.1667	1.35633
Interdependence with other projects within organisation	3.7222	1.35168
Communication within project teams and stakeholders	3.7778	1.23879
Project Environment change	4.0000	1.16554
Interaction with governments and regulatory bodies	3.8519	1.27985
Media influence	3.6481	1.38941
Total	3.76852	

Table (4.3.10) indicates that there is an influence of most of the item in the Project Management in Complexity Category by the organisations surveyed. There is some kind of reflections by the management level in the oil and gas in MENA region. The result of the means for the respondent's responses average ranged between (3.1667) and (4.0185), it reflects the level of agreement on the content of each item in the Project Management in Complexity Category.

The standard deviation of the responses reflects the low degree of dispersion, while the standard deviation ranges between (1.06333) and (1.38941); this shows the consistency in the responses response that supports the assurance of the importance of each item in the Project Management in Complexity Category in oil and gas projects in MENA region.

The researcher believes that this result was consistent with the orientations of Oil and Gas organisations in MENA concern about the projects.

4.3.6. Means and Standard Deviations of Project Performance Category

Table 4.3-11 [Means and standard deviations for each item in the Project Performance Category]

Items	Mean	SD
Technical complexity factors	2.5333	0.38461
Organisational complexity factors	2.6759	0.39090
Project Environment complexity factors	2.4019	0.56015
HSE complexity factors	2.7889	0.52149
Total	2.6	

Table (4.3.11) indicates that there is an influence of most of the item in the Project Management Performance Category by the organisations surveyed. There is some kind of reflections by the management level in the oil and gas in MENA region. The result of the means for the respondent's responses average ranged between (2.4019) and (2.7889), it reflects the level of agreement on the content of each item in the Project Performance Category.

The standard deviation of the responses reflects the low degree of dispersion, while the standard deviation ranges between (0.38461) and (0.56015); this shows the consistency in the responses response that supports the assurance of the importance of each item in the Project Performance Category in oil and gas projects in MENA region.

The researcher believes, this result was consistent with the orientations of Oil and Gas organisations in MENA concern about the projects, yet Health, Safety, & Environment (HSE) Category was major factor to affect the project performance based on the sample taken, it was expecting to have a big effect but wasn't expect to be the major factor influencing the Project Performance.

4.4. Measurement Scales

For all hypotheses, the researcher uses the Structural Equation Modelling (SEM) approach with Partial Least Square (PLS) as an analysis method. PLS has been widely used for theory testing and validation. PLS examines the psychometric properties and provides appropriate evidences on whether relationships might or might not exist

(Fornell & Larcker, 1981) In this research, the researcher performed data analysis in accordance with a two-stage methodology (Anderson & Gerbing, 1988) using Smart PLS 2.0 M3. The first step is testing the content, convergent, and discriminate validity of constructs using the measurement model, whilst the second step is testing the structural model and hypotheses (Palumbo et al., 2008).

4.4.1. Measurement Criteria for Proposed Model

1. Path loadings (factors analysis result) of suggested model

Factors analysis allows the researcher to test the hypotheses, which describes the relationship between the observed variable and their underlying latent constructs exist. As a starting point, the standardised path loadings for all indicators were above 0.55. Therefore, they are all significant (Falk & Miller, 1992). All path loadings (factors analysis result) summarise in the table (4.4.1.1), based on the figure (4.4.1.1).

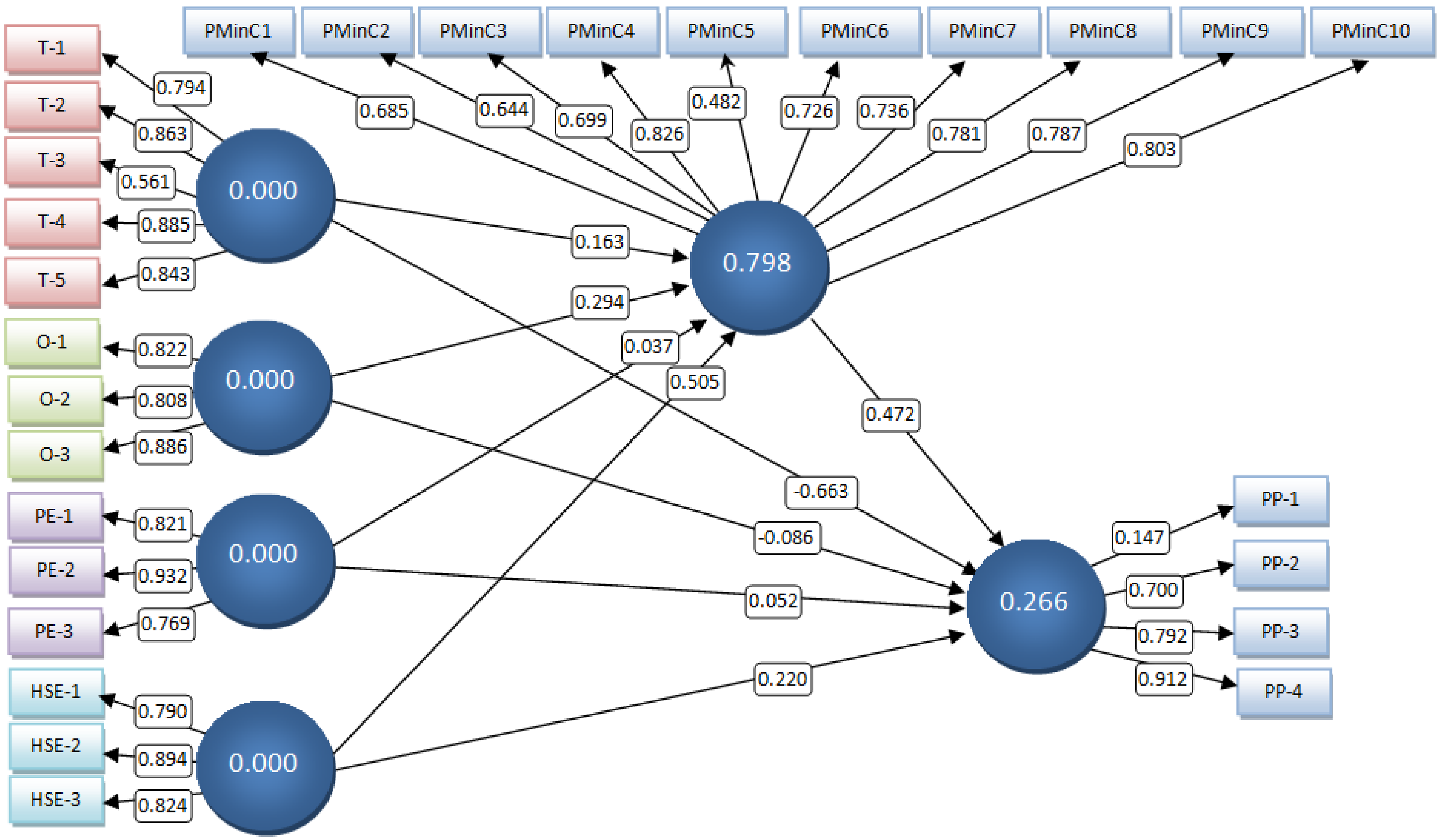


Figure 4.4.1.1 [Factors Loading for propose Model of Complexity factors on Project Performance Mediating by Project Management in complexity]

Table 4.4.1.1[Summarize of Factors Loading]

Construct	Item symbol	Factor Loading	Results
Technical Complexity	t1	0.794290	(accept)
	t2	0.863367	(accept)
	t3	0.561228	(accept)
	t4	0.885350	(accept)
	t5	0.843398	(accept)
Organisational Complexity	o1	0.821899	(accept)
	o2	0.807897	(accept)
	o3	0.886007	(accept)
Project Environment Complexity	pe1	0.821418	(accept)
	pe2	0.932356	(accept)
	pe3	0.768521	(accept)
Health, Safety and Environment Complexity	hse1	0.789766	(accept)
	hse2	0.893522	(accept)
	hse3	0.823509	(accept)

Project Management in complexity	PMinC1	0.684593	(accept)
	PMinC2	0.644153	(accept)
	PMinC3	0.698690	(accept)
	PMinC4	0.825684	(accept)
	PMinC5	**0.482357**	**(delete)**
	PMinC6	0.725049	(accept)
	PMinC7	0.736219	(accept)
	PMinC8	0.760528	(accept)
	PMinC9	0.786918	(accept)
	PMinC10	0.802659	(accept)
Project Performance	**PP1**	**0.146715**	**(delete)**
	PP2	0.699651	(accept)
	PP3	0.791908	(accept)
	PP4	0.911706	(accept)

Based on table (4.3.1) all items are accepted without (Project Management in complexity (PMinC5)) and Project Performance (PP1) because is not above 0.55, and all other item is accepted, because the standardised path loadings for all indicators were above 0.55. Therefore, they were all significant. The without (Project Management in complexity (PMinC5)) and Project Performance (PP1) is deleted.

After deleting (Project Management in complexity (PMinC5)) factor and Project Performance (PP1)) factor; the standardised path loadings for all indicators were above 0.55; therefore, they were all significant (Falk & Miller, 1992). All path loadings (factors analysis result) as modify model exist in figure (4.4.1.2).

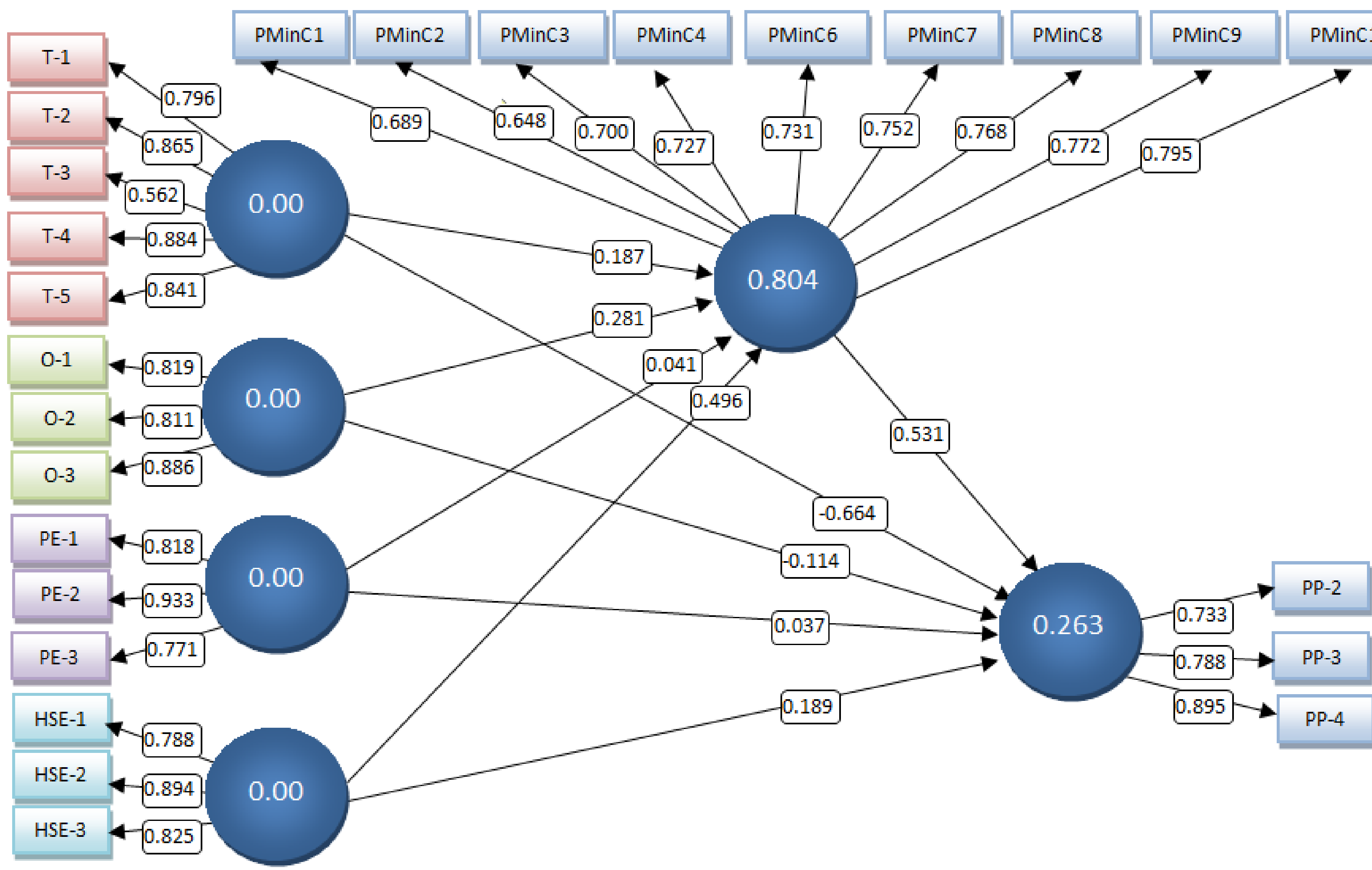


Figure 4.4.1.2[Modify Model of Complexity factors on Project Performance Mediating by Project Management in complexity]

4.4.2. Cronbach's Alpha Test

In order to achieve the reliability of the scale, Cronbach's Alpha was used. It is a common method used to measure the reliability and internal consistency of scales. Saundres et al, 2009 and Sekaran, (2007) Suggest that the reliability of the scale is accepted, if the value of Cronbach's Alpha for each construct is equal or greater than 0.60, below table (4.4.2.1) for details and analysis.

Table 4.4.2.1 [Cronbachs Alpha for all Items]

No.	Construct	No of items	Cronbach's alpha
1	**Technical Complexity**	5	0.851105
2	**Organisational Complexity**	3	0.789620
3	**Environment Complexity**	3	0.793702
4	**Health, Safety Complexity**	3	0.785450
5	**Project Management in complexity**	10	0.898486
6	**Project performance**	4	0.733719

Based on table (4.4.2.1) the constructs included within the study's model exhibit a good degree of internal consistency as the values of Cronbach's Alpha ranged from 0.733719 to 0.898486. Therefore, all Items are accepted.

4.4.3. Composite Reliability (CR) and Average Variance Extracted (AVE) Test

A Composite Reliability (CR) and Average Variance Extracted (AVE) tests were conducted to measure convergent validity. Fornell and Larcker (1981) suggested that the value of CR for each construct must exceed 0.70 whilst the value of the AVE must exceed 0.50 for the convergent validity to be assured. The CR and AVE values for the constructs included in the study model are all above acceptable levels. Therefore, they are all significant (Falk & Miller, 1992). As such: content validity, reliability, and convergent validity of the measurement instrument are all satisfactorily met in this research. See the following table (4.4.3.1).

Table 4.4.3.1 [Composite Reliability (CR) and Average Variance Extracted (AVE) for modify model]

Construct	Average Variance Extracted (AVE)	Composite Reliability (CR)
Technical Complexity	0.637458	0.895845
Organisational Complexity	0.704570	0.877199
Project Environment Complexity	0.711557	0.880277
Health, Safety and Environment Complexity	0.700115	0.874754
Project Management in complexity	0.553912	0.917481
Project performance	0.653110	0.848703

Based on table (4.4.3.1) all Average Variance Extracted (AVE) for all item of modify model are above 0.5. The researcher accepts it. Also, it has high composite reliability, based on that it was accepted. Composite Reliability (CR) for all items of modify model are above 0.7; which leads to accepting all items.

4.4.4. Discriminant Validity Assessment Test

The main important section in first step is to test discriminate validity of constructs using the measurement model. See table (4.4.4.1). As for discriminate validity, it is actually established when the square root of the AVE from the construct is greater than the correlation shared between the construct and other constructs in the model (Chin,1998).

Table 4.4.4.1 [Latent Variable Correlations (Discriminant validity)]

	Technical Com plexity	Organisational Complexity	Project Environment Complexity	Health, Safety and Environm ent Complexity	Project Management in complexity	Project performance
Technical Complexity	1.00					
Organisational Complexity	0.777533	1.00				
Environment Complexity	0.531863	0.669026	1.00			
Health, Safety and Environme nt Complexity	0.618623	0.687354	0.694433	1.00		
Project Management in complexity	0.735270	0.795940	0.674100	0.835081	1.00	
Project perform ance performance	-0.224745	-0.052129	0.097643	0.169863	0.135724	1.00

Based on above table (4.4.4.1) the discriminate validity of the measurement instrument is confirmed in this research, it given that the square root of the AVE from each construct is larger than all other cross-correlations with other constructs.

4.4.5. R^2 (R-Square) Test

Evaluation of the prediction-oriented PLS path modelling method's results for the structural model centres on the R^2 values. See Table (4.4.5.1).

Table 4.4.5.1 [R Square vales]

Construct	**R^2**
Project performance (dependent)	0. 26
Project Management in complexity (mediation)	0.80

Based on Table (4.4.5.1) The R^2 value for the dependent construct (Project performance) is 0.26 was above 25% which demonstrates an acceptable prediction level in empirical research (Gaur and Gaur, 2006) The key target construct, overall Project performance, exhibits a relatively high R^2 value of above 0.26 (i.e., the modify model explains overall Project performance by more than 26%). Indeed, the high R^2 proves the model's predictive validity (Hair, Sarstedt, Ringle, & Mena 2012 b). Also, The R^2 value for the mediating construct (Project Management in complexity) is 0.80, which demonstrate an acceptable prediction level.

The central criterion for the structural model's assessment (Henseler, Ringle, & Sarstedt, 2012), namely the coefficient of determination R^2, has a value of 0.26 for this research key target construct (Project Performance). The R^2 value substantiates the model's predictive validity (Hair et al., 2012b).

4.5. Testing hypotheses

The researcher used the systematic analysis of the proposed model to provide a detailed explanation of the results and to test all hypotheses by using Bootstrapping in smart PLS to find (T value).

Firstly, the need to find (T value) for Complexity factors (Technical, Organisational, Project Environment, and Health, Safety & Environment) on Project Performance without mediation of Project Management in complexity. The (T value) for research model is represented in Figure (4.5.1).

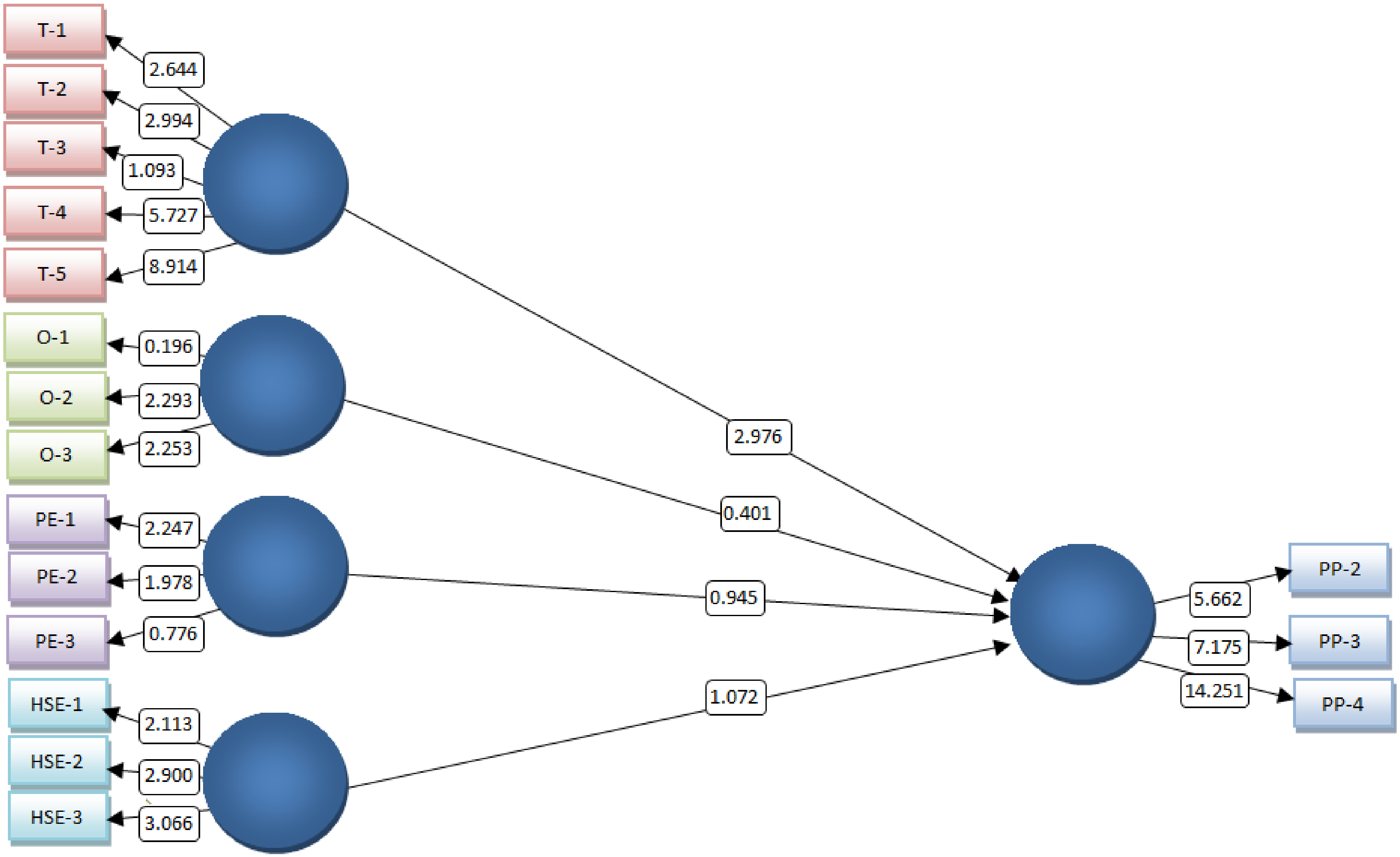


Figure 4-5-1 [Bootstrapping (T value) for Complexity factors on Project Performance without mediation of Project Management in complexity]

Based on figure (4.5.1), the researcher found that the (T value) by using the PLS to test the hypothesis related to Complexity factors (Technical, Organisational, Project Environment, and Health, Safety & Environment) on Project Performance without mediation of Project Management in complexity. Table (4.5.1) shows the summary of the result.

Table 4-5-1 [Test results of H.1.1, H.1.2, H.1.3 and H.1.4]

Relation (direct effect) **Hypothetical path**	**T value**	**Beta** **Path** **coefficient**	**Interpretation**
H.1.1: There is relation between Technical Complexity and Project Performance at ($\alpha \leq 0.05$).	2.975876	-0.663581	Supported
H.1.2: There is relation between Organisational Complexity and Project Performance at ($\alpha \leq 0.05$).	0.401276	-0.114050	Not Supported
H.1.3: There is relation between Project Environment Complexity and Project Performance at ($\alpha \leq 0.05$).	0.944930	0.037425	Not Supported
H.1.4: There is relation between Health, Safety and Environment Complexity and Project Performance at ($\alpha \leq 0.05$).	1.720351	0.189161	Supported

Referring to the table (4.5.1), the value of T is (2.975876) does exceed 1.65, which is between the Technical Complexity and Project Performance. For that reason; it was significant at the level (0.05). Additionally, the value of (Beta) is (-0.663581), which specifies the variation of one amount in Technical Complexity will cause in an adjustment of (-0.663581) amount in Project Performance. These results presented support the hypothesis: H.1.1: There is relation between Technical Complexity and Project Performance at ($\alpha \leq 0.05$).

Referring to the table (4.5.1), the value of T is (0.401276) does not exceed 1.65, which is between the Organisational Complexity and Project Performance. For that reason; it was not significant at the level (0.05). Additionally, the value of (Beta) is (-0.114050), which specifies the variation of one amount in Organisational Complexity will cause in an adjustment of (-0.114050) amount in Project Performance. These results presented not support the hypothesis: H.1.2: There is relation between Organisational Complexity and Project Performance at ($\alpha \leq 0.05$).

Referring to the table (4.5.1), the value of T is (0.944930) does not exceed 1.65, which is between the Project Environment Complexity and Project Performance. For that reason; it was not significant at the level (0.05). Additionally, the value of (Beta) is (0.037425), which specifies the variation of one amount in project Environment Complexity will cause in an adjustment of (0.037425) amount in Project Performance. These results presented not support the hypothesis: H.1.3: There is relation between project Environment Complexity and Project Performance at ($\alpha \leq 0.05$).

Referring to the table (4.5.1), the value of T is (1.720351) does exceed 1.65, which is between the Health, Safety and Environment Complexity and Project Performance. For that reason; it was significant at the level (0.05). Additionally, the value of (Beta) is (0.189161), which specifies the variation of one amount in Health, Safety & Environment Complexity will cause in an adjustment of (0.189161) amount in Project Performance. These results presented support the hypothesis: H.1.4: There is relation between Health, Safety and Environment Complexity and Project Performance at ($\alpha \leq 0.05$).

Secondly, the need to find (T value) for Complexity factors (Technical, Organisational, Project Environment, and Health, Safety & Environment) on Project Performance with mediation of Project Management in complexity. The (T value) for research model is depicted in Figure (4.5.2).

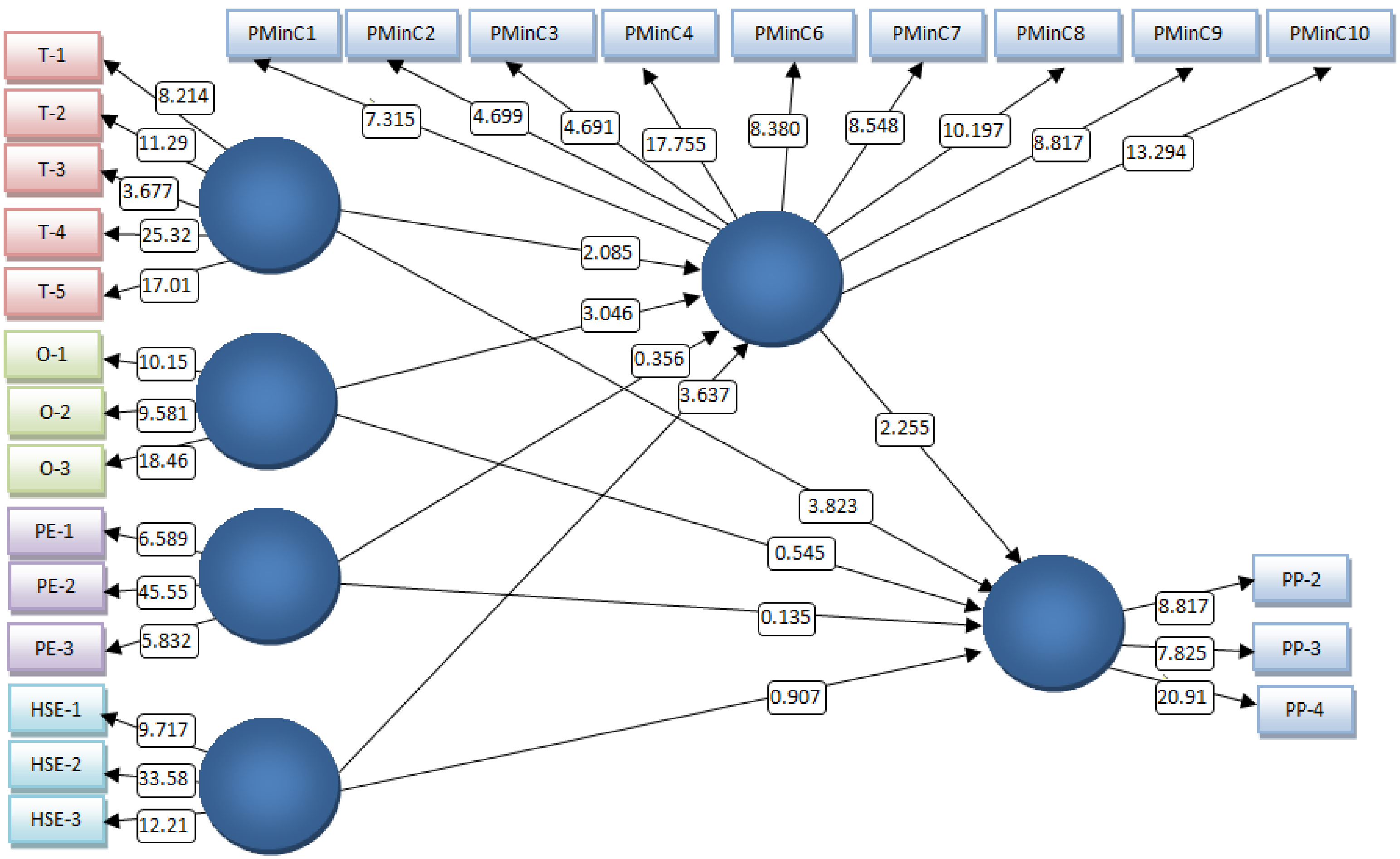


Figure 4-5-2 [Bootstrapping (T value) for Complexity factors on Project Performance with mediation of Project Management in complexity]

Based on Figure (4.5.2), the researcher found the (T value) test by using the Smart Partial Least Square (PLS) to test all hypotheses related to Complexity factors (Technical, Organisational, Project Environment, and Health, Safety & Environment) and Project Management in complexity. Table (4.5.2) shows the summary of the results. Furthermore, from Figure (4.5.2), the researcher uses the (T value) test in the Smart Partial Least Square (PLS) to examine the hypothesis associated with the Project Management in complexity, and project performance. Table (4.5.2) shows the summary of the results.

Table 4-5-2 [Test results H2.1, H2.2, H2.3, H2.4, and H3]

Relation (direct effect) **Hypothetical path**	**T value**	**Beta** **Path coefficient**	**Interpretation**
H.2.1: There is relation between Technical Complexity and Project Management in complexity *at* ($\alpha \leq 0.05$).	2.085111	0.187168	Supported
H.2.2: There is relation between Organisational Complexity and Project Management in complexity *at* ($\alpha \leq 0.05$).	3.046465	0.280821	Supported
H.2.3: There is relation between project Environment Complexity and Project Management in complexity *at* ($\alpha \leq 0.05$).	0.355074	0.040974	Not Supported

H.2.4: There is relation between Health, Safety and Environment Complexity and Project Management in complexity *at (α ≤ 0.05).*	3.637420	0.497818	Supported
H.3: There is relation between Project Management in complexity *and Project Performance at (α ≤0.05).*	2.254976	0.531220	Supported

Referring to the table (4.5.2), the value of T is (2.085111) exceed 1.65, which is between the Technical Complexity and Project Management in complexity. For that reason, it was significant at the level (0.05). Additionally, the value of (Beta) is (0.187168), which specifies the variation of one amount in Technical Complexity will cause in an adjustment of (0.187168) amount in Project Management in complexity. These results presented support the hypothesis: H.2.1: There is a relation between Technical Complexity and Project Management in complexity at (α ≤ 0.05).

Referring to the table (4.5.2), the value of T is (3.046465) exceed 1.65, which is between the Organisational Complexity and Project Management in complexity. For that reason, it was significant at the level (0.05). Additionally, the value of (Beta) is (0.280821), which specifies the variation of one amount in Organisational Complexity will cause in an adjustment of (0.280821) amount in Project

Management in complexity. These results presented support the hypothesis: H.2.2: There is a relation between Organisational Complexity and Project Management in complexity at ($\alpha \leq 0.05$).

Referring to the table (4.5.2), the value of T is (0.355074) not exceeding 1.65, which is between the Project Environment Complexity and Project Management in complexity. For that reason, it was not significant at the level (0.05). Additionally, the value of (Beta) is (0.040974), which specifies the variation of one amount in Project Environment Complexity will cause in an adjustment of (0.040974) amount in Project Management in complexity. These results presented not support the hypothesis: H.2.3: There is a relation between project Environment Complexity and Project Management in complexity at ($\alpha \leq 0.05$).

Referring to the table (4.5.2), the value of T is (3.637420) exceed 1.65, which is between the Health, Safety & Environment Complexity and Project Management in complexity. For that reason, it was significant at the level (0.05). Additionally, the value of (Beta) is (0.497818), which specifies the variation of one amount in Health, Safety & Environment Complexity will cause in an adjustment of (0.497818) amount in Project Management in complexity. These results presented support the hypothesis: H.2.4: There is a relation between Health, Safety and Environment Complexity and Project Management in complexity at ($\alpha \leq 0.05$).

Referring to the table (4.5.2), the value of T is (2.254976) exceed 1.65, which is between the between Project Management in complexity and Project Performance.

For that reason, it was significant at the level (0.05). Additionally, the value of (Beta) is (0.531220), which specifies the alteration of one amount in Project Management in complexity will cause in an alteration of (0.531220) amount in Project Performance. These results presented support the hypothesis: H.3: There is a relation between Project Management in complexity and Project Performance at ($\alpha \leq 0.05$).

The statistical the results in last section show that the T value test result was applied by the PLS to confirm the Project Management in complexity mediating the relationship between Complexity factors (Technical, Organisational, Project Environment, and Health, Safety & Environment) on Project Performance. See table (4.5.3).

Table 4-5-3 [Test results H4.1, H4.2, H4.3 and H4.4]

Hypotheses	Hypothetical path	Direct effect	Direct effect	Indirect effect	Total effect	Total effect	Interpretation
		T value	Beta Path coefficient	Beta Path coefficient	T value	Beta Path coefficient	
H4.1	Technical Complexity on Project Management in complexity	2.085111	0.187168		2.085111	0.187168	Supported
	Project Management in complexity on Project Performance	2.254976	0.531220		2.254976	0.531220	Supported
	Technical Complexity on Project Performance mediating by Project Management in complexity			0.09911			Supported partially mediate
	Technical Complexity on Project Performance	2.975876	-0.663581		3.949895	-0.56447	Supported
H4.2	Organisational Complexity on Project Management in complexity	3.046465	0.280821		3.046465	0.280821	Supported
	Project Management in complexity on Project Performance	2.254976	0.531220		2.254976	0.531220	Supported
	Organisational Complexity on Project Performance mediating by Project Management in complexity			0.1491777			Supported fully mediate
	Organisational Complexity on Project Performance	0.401276	-0.114050		0.171939	0.0351277	Not Supported

H4.3	Project Environment Complexity on Project Management in complexity	0.355074	0.040974		0.355074	0.040974	Not Supported
	Project Management in complexity on Project Performance	2.254976	0.531220		2.254976	0.531220	Supported
	Project Environment Complexity on Project Performance mediating by Project Management in complexity			0.021766			not mediate
	Project Environment Complexity on Project Performance	0.944930	0.037425		0.223914	0.0591912	Not Supported
H4.4	Health, Safety and Environment Complexity on Project Management in complexity	3.637420	0.497818		3.637420	0.497818	Supported
	Project Management in complexity on Project Performance	2.254976	0.531220		2.254976	0.531220	Supported
	Health, Safety and Environment Complexity on Project Performance mediating by Project Management in complexity			0.26445			Supported partially mediate
	Health, Safety and Environment Complexity on Project Performance	1.720351	0.189161		2.762582	0.453611	Supported

Referring to table (4.5.3), the value of T is (2.085111) exceed 1.65, which is between the Technical Complexity on Project Management in complexity. For that reason, it was significant at a level (0.05). Additionally, the T value is (2.254976) exceed

1.65, which is between the Project Management in complexity on Project Performance. For that reason, it was significant at a level (0.05).

Moreover, the value of (Beta) for (Indirect Effect) is (0.09911), which specifies the variation of one amount in Technical Complexity, and Project Management in complexity will cause in an adjustment of (0.09911) amount in Project Performance. These results accept the hypothesis H4.1: Project Management in complexity mediates the relation between Technical Complexity and Project Performance at ($\alpha \leq 0.05$).

Consequently, Project Management in complexity is a partially mediate between Technical Complexity and Project Performance in the managerial level of the oil and gas in MENA region.

The basic structural equation for this hypothesis is shown below:

Z0: Indirect effect (Project Performance).

Z1: Total effect (Project Performance).

The Indirect effect (Project Performance), and Total effect (Project Performance) value is calculated with the following formula:

Z0: Indirect effect (Project Performance) = 0.187168 (Technical Complexity) * 0.531220 (Project Management in complexity).

Z1: Total effect (Project Performance) = -0.663581 (Technical Complexity) + 0.09911 Indirect effect (Project Performance).

Empirical results reached through PLS, and structural path analysis provides empirical support to the thesis's major arguments and proposed model. First, Empirical result's analyses have underlined that oil and gas in MENA region considered (Technical Complexity) Mediation by (Project Management in complexity), and capabilities as components of their Project Performance. While such findings provide empirical support to the proposed definition, and operationalisation of the proposed model in this thesis, they should be explained in the context of the oil and gas in MENA region. The thesis's proposed model and structural path analysis have provided the empirical support to the hypotheses anticipated in the model.

Through empirically supporting for this hypothesis, findings of structural path analysis indicated a positive relationship between (Technical Complexity) Mediation by (Project Management in complexity), and their Project Performance. Indeed, the implication of this finding for oil and gas in MENA region is that they may need to pursue a combined strategy aimed at managing Technical Complexity, and Project Management in complexity to develop Project Performance.

Referring to table (4.5.3), the value of T is (3.046465) exceed 1.65, which is between the Organisational Complexity on Project Management in complexity. For that reason, it was significant at a level (0.05). Additionally, the T value is (2.254976) exceed 1.65, which is between the Project Management in complexity on Project Performance. For that reason, it was significant at a level (0.05).

Moreover, the value of (Beta) for (Indirect Effect) is (0.1491777), which specifies the variation of one amount in Organisational Complexity, and Project Management in complexity will cause in an adjustment of (0.1491777), amount in project performance. These results accept the hypothesis H4.2: Project Management in complexity mediates the relation between Organisational Complexity and Project Performance at ($\alpha \leq 0.05$).

Consequently, Project Management in complexity is a fully mediate between Organisational Complexity and Project Performance in the managerial level of the oil and gas in MENA region.

The basic structural equation for this hypothesis is shown below:

Z0: Indirect effect (Project Performance).

Z1: Total effect (Project Performance).

The Indirect effect (Project Performance), and Total effect (Project Performance) value is calculated with the following formula:

Z0: Indirect effect (Project Performance) = 0.280821 (Organisational Complexity) * 0.531220 (Project Management in complexity).

Z1: Total effect (Project Performance) = -0.114050 (Organisational Complexity) + 0.1491777 Indirect effect (Project Performance).

Empirical results reached through PLS, and structural path analysis provides empirical support to the thesis's major arguments and proposed model. First, Empirical result's analyses have underlined that oil and gas in MENA region considered (Organisational Complexity) Mediation by (Project Management in complexity), and capabilities as components of their Project Performance. While such findings provide empirical support to the proposed definition, and operationalisation of the proposed model in this thesis, they should be explained in the context of the oil and gas in MENA region. The thesis's proposed model and structural path analysis have provided the empirical support to the hypotheses anticipated in the model.

Through empirically supporting for this hypothesis, findings of structural path analysis indicated a positive relationship between (Organisational Complexity) Mediation by (Project Management in complexity), and their Project Performance. Indeed, the implication of this finding for oil and gas in MENA region is that they may need to pursue a combined strategy aimed at managing Organisational Complexity, and Project Management in complexity to develop Project Performance.

Referring to table (4.5.3), the value of T is (0.355074) does not exceed 1.65, which is between the Project Environment Complexity on Project Management in complexity. For that reason, it was not significant at a level (0.05). Additionally, the T value is (2.254976) exceed 1.65, which is between the Project Management in complexity on Project Performance. For that reason, it was significant at a level (0.05).

Moreover, the value of (Beta) for (Indirect Effect) is (0.021766), which specifies the variation of one amount in Project Environment Complexity, and Project Management in complexity will cause in an adjustment of (0.021766), amount in project performance. These results not accept the hypothesis H4.3: Project Management in complexity mediates the relation between Project Environment Complexity and Project Performance at ($\alpha \leq 0.05$).

Consequently, Project Management in complexity is not mediate between Project Environment Complexity and Project Performance in the managerial level of the oil and gas in MENA region.

The basic structural equation for this hypothesis is shown below:

Z0: Indirect effect (Project Performance).

Z1: Total effect (Project Performance).

The Indirect effect (Project Performance), and Total effect (Project Performance) value is calculated with the following formula:

Z0: Indirect effect (Project Performance) = 0.040974 (Project Environment Complexity) * 0.531220 (Project Management in complexity).

Z1: Total effect (Project Performance) = 0.037425 (Project Environment Complexity) + 0.021766 Indirect effect (Project Performance).

Empirical results reached through PLS, and structural path analysis provides empirical support to the thesis's major arguments and proposed model. First, Empirical result's analyses have underlined that oil and gas in MENA region not considered (Project Environment Complexity) Mediation by (Project Management in complexity), and capabilities as components of their Project Performance. While such findings provide empirical support to the proposed definition, and operationalisation of the proposed model in this thesis, they should be explained in the context of the oil and gas in MENA region. The thesis's proposed model and structural path analysis have provided the empirical support to the hypotheses anticipated in the model.

Through empirically supporting for this hypothesis, findings of structural path analysis indicated not a positive relationship between (Project Environment Complexity) Mediation by (Project Management in complexity), and their Project Performance. Indeed, the implication of this finding for oil and gas in MENA region is that they may need to not pursue a combined strategy aimed at managing Project Environment Complexity, and Project Management in complexity to develop Project Performance.

Referring to table (4.5.3), the value of T is (3.637420) exceed 1.65, which is between the Health, Safety and Environment Complexity on Project Management in complexity. For that reason, it was significant at a level (0.05). Additionally, the T value is (2.254976) exceed 1.65, which is between the Project Management in complexity on Project Performance. For that reason, it was significant at a level (0.05).

Moreover, the value of (Beta) for (Indirect Effect) is (0.26445), which specifies the variation of one amount in Health, Safety and Environment Complexity, and Project Management in complexity will cause in an adjustment of (0.26445), amount in project performance. These results accept the hypothesis H4.4: Project Management in complexity mediate the relation between Health, Safety & Environment Complexity and Project Performance at ($\alpha \leq 0.05$).

Consequently, Project Management in complexity is a partially mediate between Health, Safety and Environment Complexity and Project Performance in the managerial level of the oil and gas in MENA region.

The basic structural equation for this hypothesis is shown below:

Z0: Indirect effect (Project Performance).

Z1: Total effect (Project Performance).

The Indirect effect (Project Performance), and Total effect (Project Performance) value is calculated with the following formula:

Z0: Indirect effect (Project Performance) = 0.497818 (Health, Safety and Environment Complexity) * 0.531220 (Project Management in complexity).

Z1: Total effect (Project Performance) = 0.189161 (Health, Safety and Environment Complexity) + 0.26445 Indirect effect (Project Performance).

Empirical results reached through PLS, and structural path analysis provides empirical support to the thesis's major arguments and proposed model. First, Empirical result's analyses have underlined that oil and gas in MENA region considered (Health, Safety & Environment Complexity) Mediation by (Project Management in complexity), and capabilities as components of their Project Performance. While such findings provide empirical support to the proposed definition, and operationalisation of the proposed model in this thesis, they should be explained in the context of the oil and gas in MENA region. The thesis's proposed model and structural path analysis have provided the empirical support to the hypotheses anticipated in the model.

Through empirically supporting for this hypothesis, findings of structural path analysis indicated a positive relationship between (Health, Safety & Environment Complexity) Mediation by (Project Management in complexity), and their Project Performance. Indeed, the implication of this finding for oil and gas in MENA region is that they may need to pursue a combined strategy aimed at managing Health, Safety & Environment Complexity, and Project Management in complexity to develop Project Performance.

4.6. Meta-analysis

4.6.1. Data Collection

In the 110 publications on the research between project management and project complexity that were studied, the traditional view of defining project management (The Standish Group International, 1999) is still very common. Majority of the publications dealt with project success in terms of compliance with Time, Cost and Quality requirements.

In evaluating various classifications, project complexity models for the purpose of complexity factors identification in the context of projects management come to two conclusions. First, since a classification model is considered a starting point for complexity factors identification, it needs to fit the research method for which it was been used. They make a case for a survey-based study that strictly depicts the research within this context. Such a study should structure the different complexity factors groups; only then their identification can start to answer the question of "which specific complexity factors affect project management complexity?". However, the identification of project complexity is easier qualified than quantified, even if a study uses a quantitative classification model. Therefore, the second conclusion is that such a study can only be efficacious in practice if it is supported by an additional identification procedure of other studies or practitioners' adaptation.

Researcher applied this argument in emerging a complexity factors identification method consisting of a classification model through corresponding research identification questions and a procedure used on each this study. The classification model, which is adapted rely on the number of factors researchers distinguished to reflected complexity and factored based on researcher weighted importance and reflection, looking into project management literature. Many researchers have stressed the importance of theoretical grounded studies and practical participation on researches and models regarding project complexity in guiding both project management research and project complexity factors. Given that there is a significant published work on project complexity, researcher observed a great chance to accumulate the research effort and address the lack of harmony. Hence synthesise the existing body of knowledge into a more comprehensive and holistic basis of project complexity.

4.6.2. Data Analysis

Based on the literature review on project management and project complexity followed an approach similar to the protocols adopted by Meta-analysis; hence an in-depth review of project management and complexity literature, including a critical examination of the existing studies and frameworks of project management and complexity. In order to study used models of complexity in project management literature; moreover, to reform the model of current frameworks of project management and complexity, insights were drawn from a review of selected literature. Following a screening of the researches of this subject area and research nature, and after discarding nonrelated studies, an initial list of 110 studies was identified. After evaluating of the abstract of each study to assess its relevance and applicability to this type of research, this collection was further reduced to 19 studies. A study methodology assessment led to the elimination of 67 studies because they were believed not precisely applicable to the concept of Meta-analysis or not sharing the main stream of projects complexity research. Furthermore, number of studies was excluded since they only focused on few complexity factors or failed to measure the effect of complexity factor overall project complexity or did not have sufficient material on classifications and framework of project complexity. A key limiting factor in this research was the view of project complexity and the lack of agreement on defining or conceptualizing complexity in projects management.

A coding protocol was completed for each study in the analysis including author(s), publication date, type of study or research, and Importance index to reflect the complexity factor as a whole which was coded from 0-1 where zero reflect no effect and 1 as maximum effect on project complexity. Moreover, will indication the study group, study setting, importance index, plus any predictive accuracy statistics. When a given finding from the same sample was reported across multiple publications, the effect size was coded from the largest or most representative and recent sample. Then quality factor was recoded, and effect sizes recomputed. An overall rate of agreement of 96.9% was accomplished for the research factors coded and effect sizes extracted.

Table 4-6-1 [Meta-analysis projects complexity factors characteristic]

Main factors of projects complexity	Study characteristic	Importance index
A1: Goal alignment	Maylor et al. (2008)	0.10
	Remington and Pollack (2007)	025
	CIFTER (2007)	0.15
A2: Clarity of goals	Lessard et al. (2014)	0.10
	Shane et al. (2013)	0.05
	Bosch-Rekveldt et al. (2011)	0.05
	Geraldi and Adlbrecht (2007)	0.12
	Remington and Pollack (2007)	0.20
	Xia and Lee (2004)	0.12
	Williams (1999)	0.20
	Bacarini (1996)	0.30
	Shenhar and Dvir (1996)	0.10
A5 Technical complexity	Lessard et al. (2014)	0.40
	Shane et al. (2013)	0.15
	Bosch-Rekveldt et al. (2011)	0.15
	Geraldi and Adlbrecht (2007)	0.15
	Remington and Pollack (2007)	0.20
	Shenhar and Dvir (2007)	0.15
	Xia and Lee (2004)	0.10
	Bacarini (1996)	0.35
B1: Financial risks	Lu et al. (2015)	0.20
	Shane et al. (2013)	0.30
	Geraldi et al. (2011)	0.15
	Haas (2009)	0.25
	Maylor et al. (2008)	0.10
	Geraldi and Adlbrecht (2007)	0.10
	Remington and Pollack (2007)	0.05
	CIFTER (2007)	0.20
	Xia and Lee (2004)	0.05
	Williams (1999)	0.05
	Baccarini (1996)	0.05
B2: Project leadership	Lu et al. (2015)	0.15
	Shane et al. (2013)	0.10
	Geraldi, (2009)	0.30
	Remington & Pollack (2007)	0.25

C1: Safety of environment (Region, country, or city)	Lu et al. (2015) Remington and Pollack (2007) Cicmil and Marshall (2005)	0.05 0.05 0.01
C2: Political Stability of environment (Region, country, or city)	Lessard et al. (2014) Maylor et al. (2008) CIFTER (2007) Cicmil and Marshall (2005) Shenhar and Dvir (1996)	0.10 0.15 0.10 0.05 0.05
D1: Operational risks affecting processes and people	Lu et al. (2015) Lessard et al. (2014) Cicmil and Marshall (2005)	0.20 0.15 0.10
D2: Corporate environmental responsibilities	Lu et al. (2015) Lessard et al. (2014) Shane et al. (2013) CIFTER (2007)	0.10 0.15 0.10 0.13
E1: Dependencies between tasks	Lu et al. (2015) Haas (2009) Maylor et al. (2008) Cooke-Davies et al. (2007) Geraldi and Adlbrecht (2007) Remington and Pollack (2007) Jaafari (2003) Bacarini (1996)	0.20 0.15 0.20 0.25 0.30 0.20 0.35 0.45
E2: Interdependency between used Technologies	Lu et al. (2015) Maylor et al. (2008) Xia and Lee (2004)	0.05 0.05 0.15
E4: Interfaces between different disciplines	Lu et al. (2015) Haas (2009) Maylor et al. (2008) Cooke-Davies et al. (2007) Remington and Pollack (2007) Xia and Lee (2004) Jaafari (2003)	0.10 0.10 0.05 0.10 0.25 0.05 0.05
E5: Number of different cultures	Lu et al. (2015) Lessard et al. (2014) Geraldi and Adlbrecht (2007) Maylor et al. (2008)	0.05 0.10 0.05 0.10

E6: Interdependence with other projects within organisation	Lessard et al. (2014) Haas (2009) Maylor et al. (2008) Cooke-Davies et al. (2007) Geraldi and Adlbrecht (2007) Remington and Pollack (2007) Jaafari (2003) Bacarini (1996)	0.10 0.05 0.05 0.10 0.15 0.10 0.05 0.15
E7: Communication within project teams and stakeholders	Lessard et al. (2014) Bosch-Rekveldt et al. (2011) Geraldi et al. (2011) Maylor et al. (2008) Geraldi and Adlbrecht (2007) Remington and Pollack (2007) CIFTER (2007) Xia and Lee (2004) Bacarini (1996)	0.20 0.15 0.05 0.25 0.20 0.15 0.10 0.05 0.05
E8: Project Environment change	Maylor et al. (2008) Remington and Pollack (2007) Xia and Lee (2004) Bacarini (1996) Shenhar and Dvir (1996)	0.35 0.15 0.20 0.05 0.05
E9: Interaction with governments and regulatory bodies	Lessard et al. (2014) Gransberg et al. (2013) Geraldi et al. (2011) CIFTER (2007)	0.15 0.15 0.20 0.05

The problem being studied by this systematic review research is to outline the aggregated effect of each complexity factor and its interference on project complexity. Data produced from qualified studies will be analysed using Comprehensive Meta-analysis software V3 for Windows, then will be scattered into a separate quantitative approximation (Borenstein, 2014). Furthermore, the primary study outcomes of interest were effect of each complexity factor overall project complexity plus comparing the Meta-analysis findings based on project management research body of knowledge with sample of oil & gas industry perception in the MENA region. Using Comprehensive Meta-analysis software on the designated complexity factors outcomes was as below:

A1: Goal alignment

Model	Study name	Statistics for each study							Weight (Fixed)	Weight (Random)	Residual (Fixed)	Residual (Random)	Point estimate and 95% CI
		Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight	Relative weight	Std Residual	Std Residual	-1.00 -0.50 0.00 0.50 1.00
	Maylor et al.	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	62.33	62.33	-0.92	-0.92	
	Remington	0.250	0.128	0.016	-0.000	0.500	1.960	0.050	9.97	9.97	1.00	1.00	
	CIFTER	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	27.70	27.70	0.33	0.33	
Fixed		0.129	0.040	0.002	0.050	0.208	3.198	0.001					
Random		0.129	0.040	0.002	0.050	0.208	3.198	0.001					

Figure 4-6-1 [Comprehensive Meta-analysis: Goal alignment]

A2: Clarity of goals

Model	Study name	Statistics for each study							Weight (Fixed)	Weight (Random)	Residual (Fixed)	Residual (Random)	Point estimate and 95% CI
		Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight	Relative weight	Std Residual	Std Residual	-1.00 -0.50 0.00 0.50 1.00
	Lessard et al. (2014)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	8.33	9.31	0.51	0.42	
	Shane et al. (2013)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	33.33	31.08	-1.20	-1.19	
	Bosch-Rekveldt et al. (2011)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	33.33	31.08	-1.20	-1.19	
	Geraldi and Adlbrecht (2007)	0.120	0.061	0.004	0.000	0.240	1.960	0.050	5.79	6.60	0.76	0.68	
	Remington and Pollack (2007)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	2.08	2.45	1.24	1.19	
	Xia and Lee (2004)	0.120	0.061	0.004	0.000	0.240	1.960	0.050	5.79	6.60	0.76	0.68	
	Williams (1999)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	2.08	2.45	1.24	1.19	
	Bacarini (1996)	0.300	0.153	0.023	0.000	0.600	1.960	0.050	0.93	1.10	1.48	1.45	
	Shenhar and Dvir (1996)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	8.33	9.31	0.51	0.42	
Fixed		0.075	0.015	0.000	0.046	0.104	5.092	0.000					
Random		0.079	0.016	0.000	0.047	0.110	4.881	0.000					

Figure 4-6-2 [Comprehensive Meta-analysis: Clarity of goals]

A5 Technical complexity

Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lessard et al. (2014)	0.400	0.204	0.042	0.000	0.800	1.960	0.050	1.97	1.97	1.25	1.25
	Shane et al. (2013)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	14.01	14.01	0.02	0.02
	Bosch-Rekveldt et al. (2011)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	14.01	14.01	0.02	0.02
	Geraldi and Adlbrecht (2007)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	14.01	14.01	0.02	0.02
	Remington and Pollack (2007)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	7.88	7.88	0.53	0.53
	Shenhar and Dvir (2007)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	14.01	14.01	0.02	0.02
	Xia and Lee (2004)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	31.53	31.53	-1.14	-1.14
	Bacarini (1996)	0.350	0.179	0.032	-0.000	0.700	1.960	0.050	2.57	2.57	1.14	1.14
Fixed		0.148	0.029	0.001	0.092	0.204	5.175	0.000				
Random		0.148	0.029	0.001	0.092	0.204	5.175	0.000				

Figure 4-6-3 [Comprehensive Meta-analysis: Technical complexity]

B1: Financial risks

Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lu et al. (2015)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	1.30	1.68	1.34	1.29
	Shane et al. (2013)	0.300	0.153	0.023	0.000	0.600	1.960	0.050	0.58	0.76	1.54	1.51
	Geraldi et al. (2011)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	2.31	2.93	1.13	1.06
	Haas (2009)	0.250	0.128	0.016	-0.000	0.500	1.960	0.050	0.83	1.08	1.46	1.42
	Maylor et al. (2008)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	5.20	6.27	0.71	0.61
	Geraldi and Adlbrecht (2007)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	5.20	6.27	0.71	0.61
	Remington and Pollack (2007)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	20.82	19.84	-0.64	-0.68
	CIFTER (2007)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	1.30	1.68	1.34	1.29
	Xia and Lee (2004)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	20.82	19.84	-0.64	-0.68
	Williams (1999)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	20.82	19.84	-0.64	-0.68
	Baccarini (1996)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	20.82	19.84	-0.64	-0.68
Fixed		0.065	0.012	0.000	0.042	0.087	5.544	0.000				
Random		0.068	0.013	0.000	0.042	0.094	5.106	0.000				

Figure 4-6-4 [Comprehensive Meta-analysis: Financial risks]

B2: Project leadership

Model	Study name	Statistics for each study							Weight (Fixed)	Weight (Random)	Residual (Fixed)	Residual (Random)	Point estimate and 95% CI
		Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight	Relative weight	Std Residual	Std Residual	-1.00 -0.50 0.00 0.50 1.00
	Lu et al. (2015)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	25.91	25.91	0.15	0.15	
	Shane et al. 2013	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	58.29	58.29	-1.21	-1.21	
	Geraldi, (2009)	0.300	0.153	0.023	0.000	0.600	1.960	0.050	6.48	6.48	1.08	1.08	
	Remington & Pollack (2007)	0.250	0.128	0.016	-0.000	0.500	1.960	0.050	9.33	9.33	0.91	0.91	
Fixed		0.140	0.039	0.002	0.064	0.216	3.591	0.000					
Random		0.140	0.039	0.002	0.064	0.216	3.591	0.000					

Figure 4-6-5 [Comprehensive Meta-analysis: Project leadership]

C1: Safety of environment (Region, country, or city)

Model	Study name	Statistics for each study							Weight (Fixed)	Weight (Random)	Residual (Fixed)	Residual (Random)	Point estimate and 95% CI
		Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight	Relative weight	Std Residual	Std Residual	-1.00 -0.50 0.00 0.50 1.00
	Lu et al. (2015)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	3.70	23.03	1.48	0.74	
	Remington and Pollack (2007)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	3.70	23.03	1.48	0.74	
	Cicmil and Marshall (2005	0.010	0.005	0.000	-0.000	0.020	1.960	0.050	92.59	53.93	-2.13	-1.26	
Fixed		0.013	0.005	0.000	0.003	0.023	2.640	0.008					
Random		0.028	0.016	0.000	-0.003	0.059	1.794	0.073					

Figure 4-6-6 [Comprehensive Meta-analysis: Safety of environment (Region, country, or city)]

C2: Political Stability of environment (Region, country, or city)

Model	Study name	Statistics for each study							Weight (Fixed)	Weight (Random)	Residual (Fixed)	Residual (Random)	Point estimate and 95% CI
		Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight	Relative weight	Std Residual	Std Residual	-1.00 -0.50 0.00 0.50 1.00
	Lessard et al. (2014)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	9.57	9.57	0.75	0.75	
	Maylor et al. (2008)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	4.26	4.26	1.15	1.15	
	CIFTER (2007)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	9.57	9.57	0.75	0.75	
	Cicmil and Marshall (2005)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	38.30	38.30	-0.69	-0.69	
	Shenhar and Dvir (1996)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	38.30	38.30	-0.69	-0.69	
Fixed		0.064	0.016	0.000	0.033	0.095	4.043	0.000					
Random		0.064	0.016	0.000	0.033	0.095	4.043	0.000					

Figure 4-6-7 [Comprehensive Meta-analysis: Political Stability of environment (Region, country, or city)]

D1: Operational risks affecting processes and people

Model	Study name	Statistics for each study							Weight (Fixed)	Weight (Random)	Residual (Fixed)	Residual (Random)	Point estimate and 95% CI
		Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Relative weight	Relative weight	Std Residual	Std Residual	-1.00 -0.50 0.00 0.50 1.00
	Lu et al. (2015)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	14.75	14.75	0.77	0.77	
	Lessard et al. (2014)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	26.23	26.23	0.34	0.34	
	Cicmil and Marshall (2005)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	59.02	59.02	-0.85	-0.85	
Fixed		0.128	0.039	0.002	0.051	0.205	3.262	0.001					
Random		0.128	0.039	0.002	0.051	0.205	3.262	0.001					

Figure 4-6-8 [Comprehensive Meta-analysis: Operational risks affecting processes and people]

D2: Corporate environmental responsibilities

Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lu et al.	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	32.94	32.94	-0.32	-0.32
	Lessard et	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	14.64	14.64	0.52	0.52
	Shane et al.	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	32.94	32.94	-0.32	-0.32
	CIFTER	0.130	0.066	0.004	-0.000	0.260	1.960	0.050	19.49	19.49	0.28	0.28
Fixed		0.113	0.029	0.001	0.056	0.171	3.865	0.000				
Random		0.113	0.029	0.001	0.056	0.171	3.865	0.000				

Point estimate and 95% CI: -1.00, -0.50, 0.00, 0.50, 1.00

Figure 4-6-9 [Comprehensive Meta-analysis: Corporate environmental responsibilities]

E1: Dependencies between tasks

Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lu et al. (2015)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	15.66	15.66	-0.14	-0.14
	Haas (2009)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	27.84	27.84	-0.98	-0.98
	Maylor et al. (2008)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	15.66	15.66	-0.14	-0.14
	Cooke-Davies et al. (2007)	0.250	0.128	0.016	-0.000	0.500	1.960	0.050	10.02	10.02	0.30	0.30
	Geraldi and Adlbrecht (2007)	0.300	0.153	0.023	0.000	0.600	1.960	0.050	6.96	6.96	0.59	0.59
	Remington and Pollack (2007)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	15.66	15.66	-0.14	-0.14
	Jaafari (2003)	0.350	0.179	0.032	-0.000	0.700	1.960	0.050	5.11	5.11	0.78	0.78
	Bacarini (1996)	0.450	0.230	0.053	-0.000	0.900	1.960	0.050	3.09	3.09	1.05	1.05
Fixed		0.213	0.040	0.002	0.134	0.293	5.286	0.000				
Random		0.213	0.040	0.002	0.134	0.293	5.286	0.000				

Point estimate and 95% CI: -1.00, -0.50, 0.00, 0.50, 1.00

Figure 4-6-10 [Comprehensive Meta-analysis: Dependencies between tasks]

E2: Interdependency between used Technologies

Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lu et al. (2015)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	47.37	47.37	-0.28	-0.28
	Maylor et al. (2008)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	47.37	47.37	-0.28	-0.28
	Xia and Lee (2004)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	5.26	5.26	1.27	1.27
Fixed		0.055	0.018	0.000	0.021	0.090	3.148	0.002				
Random		0.055	0.018	0.000	0.021	0.090	3.148	0.002				

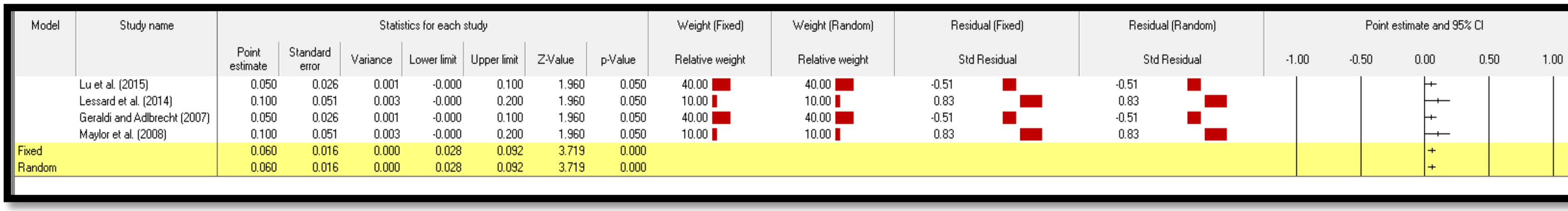
Figure 4-6-11 [Comprehensive Meta-analysis: Interdependency between used Technologies]

E4: Interfaces between different disciplines

Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lu et al. (2015)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	6.60	6.60	0.77	0.77
	Haas (2009)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	6.60	6.60	0.77	0.77
	Maylor et al. (2008)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	26.39	26.39	-0.55	-0.55
	Cooke-Davies et al. (2007)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	6.60	6.60	0.77	0.77
	Remington and Pollack (2007)	0.250	0.128	0.016	-0.000	0.500	1.960	0.050	1.06	1.06	1.48	1.48
	Xia and Lee (2004)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	26.39	26.39	-0.55	-0.55
	Jaafari (2003)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	26.39	26.39	-0.55	-0.55
Fixed		0.062	0.013	0.000	0.036	0.088	4.732	0.000				
Random		0.062	0.013	0.000	0.036	0.088	4.732	0.000				

Figure 4-6-12 [Comprehensive Meta-analysis: Interfaces between different disciplines]

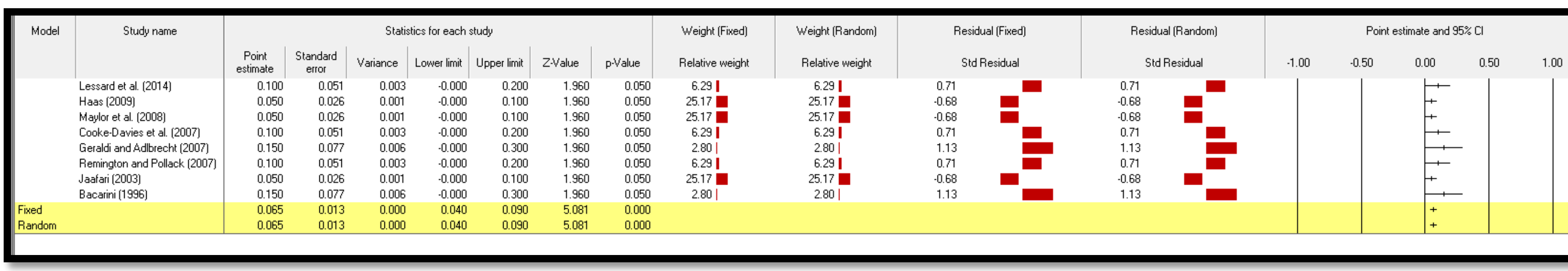
E5: Number of different cultures



Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lu et al. (2015)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	40.00	40.00	-0.51	-0.51
	Lessard et al. (2014)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	10.00	10.00	0.83	0.83
	Geraldi and Adlbrecht (2007)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	40.00	40.00	-0.51	-0.51
	Maylor et al. (2008)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	10.00	10.00	0.83	0.83
Fixed		0.060	0.016	0.000	0.028	0.092	3.719	0.000				
Random		0.060	0.016	0.000	0.028	0.092	3.719	0.000				

Figure 4-6-13 [Comprehensive Meta-analysis: Number of different cultures]

E6: Interdependence with other projects within organisation



Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lessard et al. (2014)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	6.29	6.29	0.71	0.71
	Haas (2009)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	25.17	25.17	-0.68	-0.68
	Maylor et al. (2008)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	25.17	25.17	-0.68	-0.68
	Cooke-Davies et al. (2007)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	6.29	6.29	0.71	0.71
	Geraldi and Adlbrecht (2007)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	2.80	2.80	1.13	1.13
	Remington and Pollack (2007)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	6.29	6.29	0.71	0.71
	Jaafari (2003)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	25.17	25.17	-0.68	-0.68
	Bacarini (1996)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	2.80	2.80	1.13	1.13
Fixed		0.065	0.013	0.000	0.040	0.090	5.081	0.000				
Random		0.065	0.013	0.000	0.040	0.090	5.081	0.000				

Figure 4-6-14 [Comprehensive Meta-analysis: Interdependence with other projects within organisation]

E7: Communication within project teams and stakeholders

Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lessard et al. (2014)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	1.72	2.40	1.32	1.24
	Bosch-Rekveldt et al. (2011)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	3.05	4.16	1.10	1.00
	Geraldi et al. (2011)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	27.49	25.53	-0.78	-0.84
	Maylor et al. (2008)	0.250	0.128	0.016	-0.000	0.500	1.960	0.050	1.10	1.56	1.44	1.38
	Geraldi and Adlbrecht (2007)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	1.72	2.40	1.32	1.24
	Remington and Pollack (2007)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	3.05	4.16	1.10	1.00
	CIFTER (2007)	0.100	0.051	0.003	-0.000	0.200	1.960	0.050	6.87	8.73	0.67	0.52
	Xia and Lee (2004)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	27.49	25.53	-0.78	-0.84
	Bacarini (1996)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	27.49	25.53	-0.78	-0.84
Fixed		0.067	0.013	0.000	0.041	0.093	5.001	0.000				
Random		0.073	0.016	0.000	0.041	0.105	4.537	0.000				

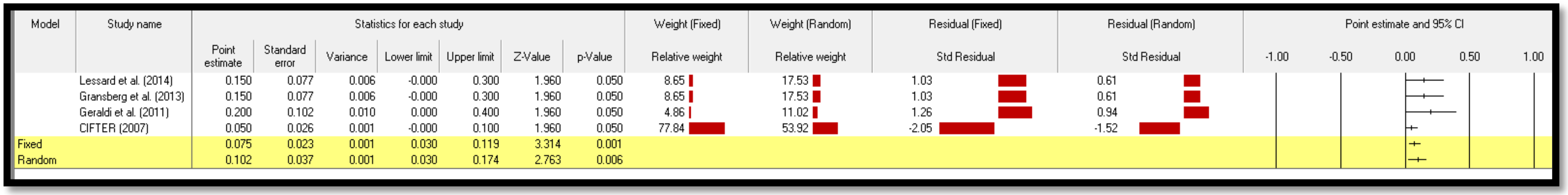
Figure 4-6-15 [Comprehensive Meta-analysis: Communication within project teams and stakeholders]

E8: Project Environment change

Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Maylor et al. (2008)	0.350	0.179	0.032	-0.000	0.700	1.960	0.050	0.93	2.18	1.62	1.52
	Remington and Pollack (2007)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	5.06	10.31	1.18	0.93
	Xia and Lee (2004)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	2.85	6.24	1.37	1.19
	Bacarini (1996)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	45.58	40.63	-0.64	-0.81
	Shenhar and Dvir (1996)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	45.58	40.63	-0.64	-0.81
Fixed		0.062	0.017	0.000	0.028	0.096	3.607	0.000				
Random		0.076	0.027	0.001	0.024	0.129	2.841	0.004				

Figure 4-6-16 [Comprehensive Meta-analysis: Project Environment change]

E9: Interaction with governments and regulatory bodies



Model	Study name	Point estimate	Standard error	Variance	Lower limit	Upper limit	Z-Value	p-Value	Weight (Fixed) Relative weight	Weight (Random) Relative weight	Residual (Fixed) Std Residual	Residual (Random) Std Residual
	Lessard et al. (2014)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	8.65	17.53	1.03	0.61
	Gransberg et al. (2013)	0.150	0.077	0.006	-0.000	0.300	1.960	0.050	8.65	17.53	1.03	0.61
	Geraldi et al. (2011)	0.200	0.102	0.010	0.000	0.400	1.960	0.050	4.86	11.02	1.26	0.94
	CIFTER (2007)	0.050	0.026	0.001	-0.000	0.100	1.960	0.050	77.84	53.92	-2.05	-1.52
Fixed		0.075	0.023	0.001	0.030	0.119	3.314	0.001				
Random		0.102	0.037	0.001	0.030	0.174	2.763	0.006				

Figure 4-6-17 [Comprehensive Meta-analysis: Interaction with governments and regulatory bodies]

Table 4-6-2 [Benchmarking with Meta-analysis outcomes with O&G survey]

	Item symbol	Factor Loading	Factor importance
Technical Complexity	T1	0.794	**0.129**
	T2	0.863	**0.075**
	T5	0.843	**0.029**
Organisational Complexity	O1	0.822	**0.065**
	O2	0.808	**0.140**
Project Environment Complexity	PE1	0.821	**0.013**
	PE2	0.932	**0.065**
Health, Safety and Environment Complexity	HSE1	0.790	**0.128**
	HSE2	0.894	**0.113**
Project Management in complexity	PMinC1	0.685	**0.213**
	PMinC2	0.644	**0.055**
	PMinC4	0.826	**0.062**
	PMinC5	0.482	**0.060**
	PMinC6	0.725	**0.065**
	PMinC7	0.736	**0.067**
	PMinC8	0.761	**0.062**
	PMinC9	0.787	**0.075**

Based on Meta-analysis results shows four factors that play an enlarged role in project complexity according to project management academic body: Goal alignment, Project leadership, Operational risks affecting processes and people, and finally Dependencies between tasks. Of course, this taxonomy echoes researcher study of oil & gas projects complexity factors in MENA region, with the involvement for those factors according to academia in multidiscipline in projects management.

Worth noting that project management sees different cultures have major effect in increasing project complexity, while oil & gas community don't really consider it as contributing factor to make projects as complex as other factors.

A key limiting factor in assessing the conception of project complexity is the lack of consensus in the definition or foundation of complexity in projects, which make it very challenging to quantify or enumerate the factors or even benchmark them to industry standard or common agreement within academics or practitioners.

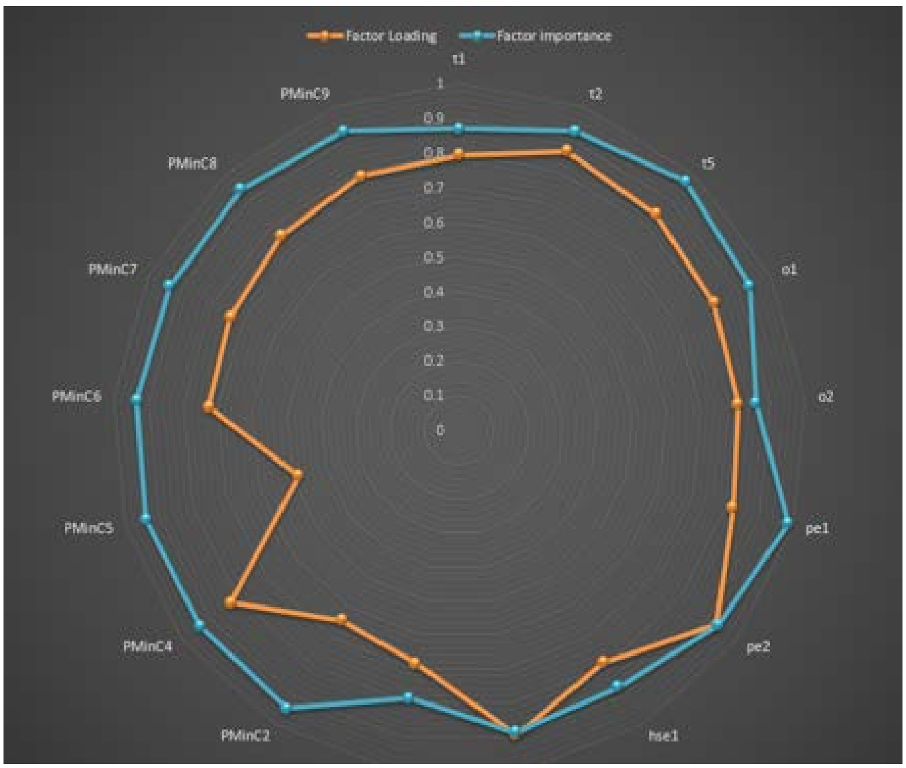


Figure 4-6-18 [Benchmarking with Meta-analysis outcomes with O&G survey]

In order to diminish publication bias, efforts to eliminate irrelative studies resulted in improving research results. A funnel plot displaying standard error of Hedges' g was generated, plus estimation the potential publication bias. The funnel plot as per figure 4-6-19 represents a symmetrical illustration of studies about the effect size; resembling a funnel shape. This illustration indicates an absence of publication bias (Borenstein et al., 2009).

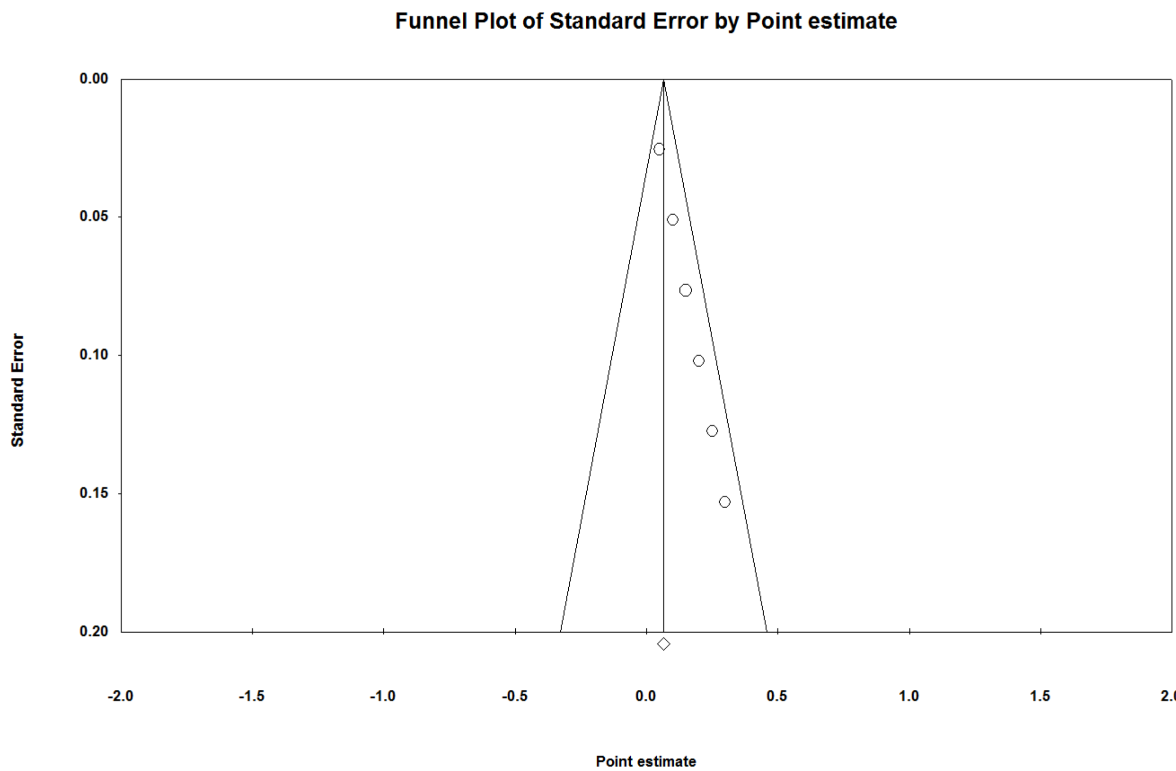


Figure 4-6-19 [Funnel Plot of Standard Error of Hedges' g]

4.7. Summary

This chapter contains three stages; first organising the data for analysis, then utilises a descriptive statistics in order to outline the information extracted from raw data. Finally, the researcher will test hypotheses and model aiming to validate results. In this phase, a questionnaire that was developed according to research objectives was distributed among the chosen sample. Which was involved an engineering society working in project management environment and data collection will be based on snowball sampling. Moreover, the researcher conducted a detailed interview with managers with a solid understanding of executing projects in complexity and a clear view of various factors that contribute towards project complexity and how this could affect project performance..

Furthermore, Meta-analysis, a statistical technique combines and contrasts the findings of independent studies in the project complexity field. It intends to cover all the related and independent studies, look for the presence of heterogeneity, identify patterns and aims to achieve robust conclusions by using sensitivity analysis. Quality effects models can facilitate the outcome by giving weight to higher quality research completed in the Projects complexity (Cooper et al., 2009).

The results obtained from the questionnaire surveys were divided into below sections;

Technical Category, Organisational Category, Project Environment Category, Health, Safety, and Environment (HSE) Category, Project Management in

Complexity Category, and Project Performance Category. The results are shown as a combination of statistical details and percentages and include bullet point summaries of comments made by the researcher. The researcher uses the Structural Equation Modelling (SEM) approach with Partial Least Square (PLS) as an analysis method. PLS has been used to examine the psychometric properties and provides appropriate evidence on whether relationships might or might not exist. In this research, the researcher performed data analysis in accordance with a two-stage methodology using Smart PLS 2.0 M3. The first step is testing the content, convergent, and discriminate validity of constructs using the measurement model, whilst the second step is testing the structural model and hypotheses.

Factors analysis allows the researcher to test the hypotheses, which describe the relationship between the observed variable and their underlying latent constructs exist. As a starting point, the standardised path loadings for all indicators were above 0.55. Therefore, they are all significant (Falk & Miller, 1992), except Project Management in complexity (PMinC5) and Project Performance (PP1) because is not above 0.55.

In order to achieve the reliability of the scale, Cronbach's Alpha was used. It is a common method used to measure the reliability and internal consistency of scales (Saundres et al., 2009) and (Sekaran, 2007). Suggest that the reliability of the scale is accepted, if the value of Cronbach's Alpha for each construct is equal or greater than 0.60. The constructs included within the study's model exhibit a good degree of internal consistency as the values of Cronbach's Alpha ranged from 0.733719 to 0.898486. Therefore, all Items are accepted. Moreover CR and AVE values for the constructs included in the study model are all above acceptable levels. Therefore, they are all significant. The R^2 value for the dependent construct (Project performance) is 0.26 was above 25% which demonstrates an acceptable prediction level in empirical research. The key target construct, overall Project performance, exhibits a relatively high R^2 value of above 0.26 (i.e., the modified model explains overall Project performance by more than 26%). Indeed, the high R^2 proves the model's predictive validity. Also, The R^2 value for the mediating construct (Project Management in complexity) is 0.80, which demonstrates an acceptable prediction level.

The researcher found the (T value) test by using the Smart Partial Least Square (Smart-PLS) to test all hypotheses related to Complexity factors (Technical, Organisational, Project Environment, and Health, Safety & Environment) and Project Management in complexity. Furthermore, the researcher uses the (T value) test in the Smart Partial Least Square (Smart-PLS) to examine the hypothesis associated with the Project Management in complexity, and project performance.

The value of T is (2.085111) exceed 1.65, which is between the Technical Complexity and Project Management in complexity. For that reason, it was significant at the level (0.05). Additionally, the value of (Beta) is (0.187168), which specifies the variation of one amount in Technical Complexity will cause in an adjustment of (0.187168) amount in Project Management in complexity. These results presented support the hypothesis: H.2.1: There is a relation between Technical Complexity and Project Management in complexity at ($\alpha \leq 0.05$).

The value of T is (3.046465) exceed 1.65, which is between the Organisational Complexity and Project Management in complexity. For that reason, it was significant at the level (0.05). Additionally, the value of (Beta) is (0.280821), which specifies the variation of one amount in Organisational Complexity will cause in an adjustment of (0.280821) amount in Project Management in complexity. These results presented support the hypothesis: H.2.2: There is a relation between Organisational Complexity and Project Management in complexity at ($\alpha \leq 0.05$).

The value of T is (0.355074) not exceeding 1.65, which is between the Project Environment Complexity and Project Management in complexity. For that reason, it was not significant at the level (0.05). Additionally, the value of (Beta) is (0.040974), which specifies the variation of one amount in Project Environment Complexity will cause in an adjustment of (0.040974) amount in Project Management in complexity. These results presented not support the hypothesis: H.2.3: There is a relation between project Environment Complexity and Project Management in complexity at ($\alpha \leq 0.05$).

The value of T is (3.637420) exceed 1.65, which is between the Health, Safety & Environment Complexity and Project Management in complexity. For that reason, it was significant at the level (0.05). Additionally, the value of (Beta) is (0.497818), which specifies the variation of one amount in Health, Safety & Environment Complexity will cause in an adjustment of (0.497818) amount in Project Management in complexity. These results presented support the hypothesis: H.2.4: There is a relation between Health, Safety and Environment Complexity and Project Management in complexity at ($\alpha \leq 0.05$).

The value of T is (2.254976) exceed 1.65, which is between the between Project Management in complexity and Project Performance. For that reason, it was significant at the level (0.05). Additionally, the value of (Beta) is (0.531220), which specifies the alteration of one amount in Project Management in complexity will cause in an alteration of (0.531220) amount in Project Performance. These results presented support the hypothesis: H.3: There is a relation between Project Management in complexity and Project Performance at ($\alpha \leq 0.05$).

The statistical results in the last section show that the T value test result was applied by the PLS to confirm the Project Management in complexity mediating the relationship between Complexity factors (Technical, Organisational, Project Environment, and Health, Safety & Environment(HSE)) on Project Performance.

Table 4-6-3 [Summary of hypotheses Test results H4.1, H4.2, H4.3 and H4.4]

Hypotheses	Hypothetical path	Interpretation
H4.1	Technical Complexity on Project Management in complexity	Supported
	Project Management in complexity on Project Performance	Supported
	Technical Complexity on Project Performance mediating by Project Management in complexity	Supported partially mediate
	Technical Complexity on Project Performance	Supported
H4.2	Organisational Complexity on Project Management in complexity	Supported
	Project Management in complexity on Project Performance	Supported
	Organisational Complexity on Project Performance mediating by Project Management in complexity	Supported fully mediate
	Organisational Complexity on Project Performance	Not Supported
H4.3	Project Environment Complexity on Project Management in complexity	Not Supported
	Project Management in complexity on Project Performance	Supported
	Project Environment Complexity on Project Performance mediating by Project Management in complexity	not mediate
	Project Environment Complexity on Project Performance	Not Supported
H4.4	Health, Safety and Environment Complexity on Project Management in complexity	Supported
	Project Management in complexity on Project Performance	Supported
	Health, Safety and Environment Complexity on Project Performance mediating by Project Management in complexity	Supported partially mediate
	Health, Safety and Environment Complexity on Project Performance	Supported

Through empirically supporting for those hypothesis, findings of structural path analysis indicated a positive relationship between (Technical Complexity, Organisational Complexity, and Health, Safety & Environment Complexity) Mediation by (Project Management in complexity), and their Project Performance. Indeed, the implication of this finding for oil and gas in MENA region is that they may need to pursue a combined strategy aimed at managing Technical

Complexity, Organisational Complexity, and Health, Safety & Environment Complexity, and Project Management in complexity to improve Project Performance and outcomes. Furthermore Organisational Complexity was of the most significance on Project Performance and Project Environment Complexity was not a positive relationship between Project Environment Complexity Mediation by Project Management in complexity, and their Project Performance.

Regarding Meta-analysis research strategy, a total of 110 publications on the research subject between project management and project complexity were studied. Majority of the publications dealt with project success in terms of compliance with Time, Cost and Quality requirements. In evaluating various classifications, project complexity models for the purpose of complexity factors identification in the context of projects management come to two conclusions. First, since a classification model is considered a starting point for complexity factors identification, it needs to fit the research method for which it was been used. However, the identification of project complexity is easier qualified than quantified, even if a study uses a quantitative classification model. Therefore, the second conclusion is that such a study can only be efficacious in practice if it is supported by an additional identification procedure of other studies or practitioners' adaptation. Following a screening of the researches of this subject area and research nature, and after discarding nonrelated studies, an initial list of

110 studies was identified. After evaluating of the abstract of each study to assess its relevance and applicability to this type of research, this collection was further reduced to 19 studies. A study methodology assessment led to the elimination of 67 studies because they were believed not precisely applicable to the concept of Meta-analysis or not sharing the main stream of projects complexity research. Furthermore, number of studies was excluded since they only focused on few complexity factors or failed to measure the effect of complexity factor overall project complexity or did not have sufficient material on classifications and framework of project complexity. A key limiting factor in this research was the view of project complexity and the lack of agreement on defining or conceptualizing complexity in projects management.

Table 4-6-4 [Benchmarking with Meta-analysis outcomes with O&G survey]

	Factor symbol	Factor Loading	Factor importance
Technical Complexity	T1	0.794	**0.129**
	T2	0.863	**0.075**
	T5	0.843	**0.029**
Organisational Complexity	O1	0.822	**0.065**
	O2	0.808	**0.140**
Project Environment Complexity	PE1	0.821	**0.013**
	PE 2	0.932	**0.065**
Health, Safety and Environment Complexity	HSE1	0.790	**0.128**
	HSE2	0.894	**0.113**
Project Management in complexity	PMinC1	0.685	**0.213**
	PMinC2	0.644	**0.055**
	PMinC4	0.826	**0.062**
	PMinC5	0.482	**0.060**
	PMinC6	0.725	**0.065**
	PMinC7	0.736	**0.067**
	PMinC8	0.761	**0.062**
	PMinC9	0.787	**0.075**

Based on Meta-analysis results shows four factors that play an enlarged role in project complexity according to project management academic body: Goal alignment, Project leadership, Operational risks affecting processes and people, and finally Dependencies between tasks. Of course, this taxonomy echoes researcher study of oil & gas projects complexity factors in MENA region, with the involvement of those factors according to academia in multidiscipline in projects management.

Worth noting that project management sees different cultures have a major effect in increasing project complexity, while oil & gas community don't really consider it as contributing factor to make projects as complex as other factors.

A key limiting factor in assessing the conception of project complexity is the lack of consensus in the definition or foundation of complexity in projects, which make it very challenging to quantify or enumerate the factors or even benchmark them to industry standard or common agreement within academics or practitioners.

5. Discussion, conclusions and recommendations

5.1. Introduction

The final chapter of this thesis illustrates an argument of the results obtained during the course of the research and the subsequent analysis that was accomplished; the narrative draws upon the original aims and objectives of the study and considers the implications, limitations and contribution to knowledge. Recommendations for further research are demonstrated and explained, the importance of complexity factors plus the pedagogical systems design and management for projects in complexity considerations that are essential to the success of complex Oil & Gas projects and programmes.

Research approach was developed to solve the research problem and accomplish the objectives. In order to endeavour such a complex problem, firstly, the research scope was limited to cover the oil and gas (O & G) engineering project society in the Middle East and North Africa (MENA). Since this research used qualitative survey strategy then Meta-analysis strategy, researcher develop two fragments of hypothesis to match research strategy used. The first phase involves the development of a questionnaire and unstructured interviews. As for the second part, Meta- analysis will be used to study the correlation between the complexity factors under focus in order to understand the common complexity factors within research under investigation. Aiming for the presence of heterogeneity, identify patterns and aims to achieve robust conclusions by using sensitivity analysis.

Quality effects models can facilitate the outcome by giving weight for higher quality research completed in the Projects complexity.

Researcher uses the Structural Equation Modelling (SEM) approach with Partial Least Square (PLS) as an analysis method. PLS has been widely used for theory testing and validation. In this research, the researcher performed data analysis in accordance with a two-stage methodology (Anderson & Gerbing, 1988) using Smart PLS 2.0 M3. The first step is testing the content, convergent, and discriminate validity of constructs using the measurement model, whilst the second step is testing the structural model and hypotheses (Palumbo et al., 2008). The findings include significant relation between Technical Complexity, Health, Safety and Environment Complexity and Project Performance even without mediation of Project Management in complexity. While Organisational Complexity elevated to significant level once Project Management in Complexity factors only when considering Project Management in Complexity (PMinC) as mediator. That supports the necessity to pursue a combined strategy aimed at managing Technical Complexity plus Health, Safety & Environment Complexity factors at internal level of projects and programmes. While Organisational Complexity factors need to be considered with project context and environment based on factor of connectivity and dependency which normally enlarged in condition of project in complexity

Within subcategories of complexity factors combined strategies based in interconnected factors anticipated to play enlarged role and projected to form new paradigm based on feedback loops between such factors. Hence required to be considered as form of system within systems to be able to tackle there consequences with right stagey and precise methods.

Based on Meta-analysis results shows four factors that play an enlarged role in project complexity according to project management academic body: Goal alignment, Project leadership, Operational risks affecting processes and people, and finally Dependencies between tasks. Of course, this taxonomy echoes researcher study of oil & gas projects complexity factors in MENA region, with the involvement for those factors according to academia in multidiscipline in projects management. Worth mentioning that project management sees different cultures have major effect in increasing project complexity, while oil & gas community don't really consider it as contributing factor to make projects as complex as other factors.

5.2. Complexity lenses

Now that we understand what is the landscape model for factors affect projects in complexity. It's required to consider are two main things to cope with complexity in projects, firstly the type of complexity landscape we are dealing with and secondly the types of strategies cope with these different complexity landscapes.

Initially, the type of complexity landscapes, there are a number of different factors that will define the overall complexity landscape. Initially studying how different factors contribute to the complexity landscape. Hence Technical, Organisational, Project Environment, Health, Safety, & Environment (HSE) and lastly Project Management in Complexity landscapes and its associated complexity factors determine which landscape critical at this particulate timeframe. Next based on the current critical complexity landscape(s) a dominant strategy will significantly govern the programme/project strategic dimension with its practical solutions, for example in terms of complexity factors the Instability of Oil Prices was the most critical to motivate the Project Environment complexity landscape. It will influence the fitness landscape of the different methods we would see one dominant strategy or theme in all projects and programmes.

Then there will be the lens of dynamics of the project complexity. Since we are dealing with projects where complexity conditions may remain relatively stable for extended periods of time or as most of the times dealing with emerging markets and environments where the context is changing rapidly causing ascending and descending to the complexity landscape. Hence, a feedback to strategy will keep landscape intact.

Finally, the interdependency of different complexity factors, landscapes, organisations and industry environment, which coined by the researcher as Project Management in Complexity (PMinC), therefore, it is the capacity for a project or programme to respond to changes within its environment, which lead the organisation and its projects on the macro scale to reconfigure itself to respond to the input of a change and stay adapting for an extended period.

Figure 5-1 [Types of complexity landscapes]

Interviews with senior manager mainly representing five major organisations in Oil & Gas industry within MENA region, the researcher engaged with interviewees to confirm their own opinions regarding different complexity factors and landscapes plus the strategy to cope with different complexity landscapes.

5.3. Discussions and conclusions

The fundamental base for complexity theory is its effort to enlighten complex system not fully understandable using the traditional theories. It integrates the complex behaviour as it emerges from simple rules, yet it's focused on the network structure of complex systems and the interdependency of those systems that evolve the simple rules outcome to form an emergent behaviour for the whole system(s). This ability to build adaptive capacity what makes the complexity in system and projects attractive aspect; since it will be inherited within the strategic level and form systems dynamics that maximise benefits for organisations and support team complex collaboration. This paradigm shift is what guides this research and its focus to find deep complexity factors within oil & gas projects and organisations to address those areas via the complexity lenses then try to build the adaptive capacity and modelling systems dynamics based on factors of major influence.

Considering the holistic approach when dealing with large and complex projects through the lenses of systems thinking, such projects are composed of many specialised disciplines and teams. Then the main focus has to be the whole project or programme integration (self- organising theme), i.e. the overall foundation through the project or programme are interconnected into an operational paradigm by adapting systematic view of the project. This self- organising paradigm will primarily concern with generating and performing an interconnection and interactions among the elements of the entire project, that will ensure the customer and stakeholder's requirements are fulfilled in high quality, cost-efficient, reliable and schedule compliant routine during the project's entire life-cycle.

This unconventional approach or paradigm of handling projects in organisations as dynamic entities exposed to internal and external changes, and then in order to succeed over time, they have to embrace the capability to navigate this changing environment and build the adaptability and agility. The organisation needs to be able to define long-term objectives, and endorse emergent behaviour within interacting elements and projects allowing positive results. This context of interaction synergies based on interdependence and positive feedback loops, which will support a self-reinforcing that accelerate growth cycle. The rise of coherent model in organisations enables connectivity to internal and external collaborative socio-technical systems and its volatile environments.

Our energy world dependency model reflect all aspects of our routines and integration with other systems and their environments, in order to realise not just subsystem optimisation but efficiency on the macro scale, it is required an integrated and more holistic approach to design engineering project in Oil & Gas industry and economics. Other factors inspire this interacting context IT revolution and economic globalisation, where synergies aid achieving the emergence of new levels of organisation and system functionality. This phenomenon of emergence open the door to a whole new level of organisation can be acknowledged, which then starts to interact with other organisations within its environment.

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5.4. Contribution to knowledge

The research has important contributions for shedding light on projects management in complexity within Oil & Gas industry and relates that foundation with the entire engineering projects management; since it targeted the objective of exploring factors affected complexity in Oil & Gas projects. The research was trying to define what exactly the factors affect complexity in oil & gas projects first as individual factors before going into looking at complexity as an artefact of a number of different complexity factors, which was called projects in complexity factors. Many different Perspectives such as Nonlinearity, interdependency, Adaptation and self-organisation with their commonalities were also considered. Finally, the researcher tried to propose a perception of the implication and context of complexity theory to extend oil & gas projects body of knowledge into the world of nonlinear systems. Keening to generate a framework or conception that helps organise and interpret projects in complexity, forming cooperation as another lens through which synchronisation and coordination facilitate the rise of local and global patterns of self-organisation. When the project operates in a dynamic state far from its equilibrium, what so called the edge of chaos state, provided with sufficient entropy for some fluctuation to materialise and become amplified into a new pattern of “order”. This pattern of order needs dependency on a set of inputs from its environment in order to maintain robustness hence it can sustain its functionality, plus sufficient resilience to be able to response when required to balance the anxiety from its environment or within organisation, thus maintain its internal configuration within the required state to preserve its structure.

This research has contributed to the current body of knowledge in managing complexity in Oil & Gas Projects. Prior to this research, there was a poor focus on how to evaluate or to cope with complexity in projects. Besides any assessment to recognise and categorise complexity in Oil & Gas projects plus their impact level. This will help to identify practices and strategies which support project managers in managing complex projects.

5.5. Recommendations for future research

The recommendations of this research were developed with input from practitioners and professional as well as academics in collaboration with oil and gas projects managers in the Middle East and North Africa region and their desires for focusing on building a complexity enabled methods to embrace complexity in projects, Whilst not radically shifting the underlying principles of oil and gas projects engineering and management.

Hence, additional research to value those complexity factors in Oil & Gas projects and embracing this framework of this research; in order to adopt new methods for engineering and managing projects in complexity. Then use evaluation approach to evaluate the outcomes based manipulate complexity factors (adopt, observe and evaluate the proposed framework) is recommended. Based on this the evaluation of a real-world project should be carried out to examine the factors effects and outcomes of the proposed framework in oil and gas engineering, to explore the values to the framework in creating positive outcomes and having an evaluation for the overall complexity factors effects of the framework from a holistic perception..

In addition, the research didn't segregate between levels of complexity with any scale measures; it only qualitatively recognised complexity. Therefore, future researches could also include a phase to develop a dimension to complexity level to assess the complexity factors against affected complexity level. Other recommended area is including embracing defined managerial responses when dealing with complexity factors at unpredictable levels of complexity. Moreover could look at best ways to developed future response plans based on research design. In order to discover successful empirical methods for mapping the project management team competencies and methodologies required for copying with the complexity levels. This complexity profile can be utilised as the basis for developing a framework of competencies and methodologies that shape the practitioner knowledge, expertise, and proficiency qualities mandate how to embrace and cope with project complexity.

Finally future research should focus on testing such model in real-life projects in Oil & Gas sector by testing the complexity science concepts partially or full model the PMO. Such practices will impact the model behaviour and relationships of projects and teams then will be reflected on outcomes both operationally and firm-level performance.

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Appendix 1: Research Data (Smart PLS Models & Diagrams)

Partial Least Squares- Structural Equation Modeling (PLS-SEM)

Technical Category (NEW)

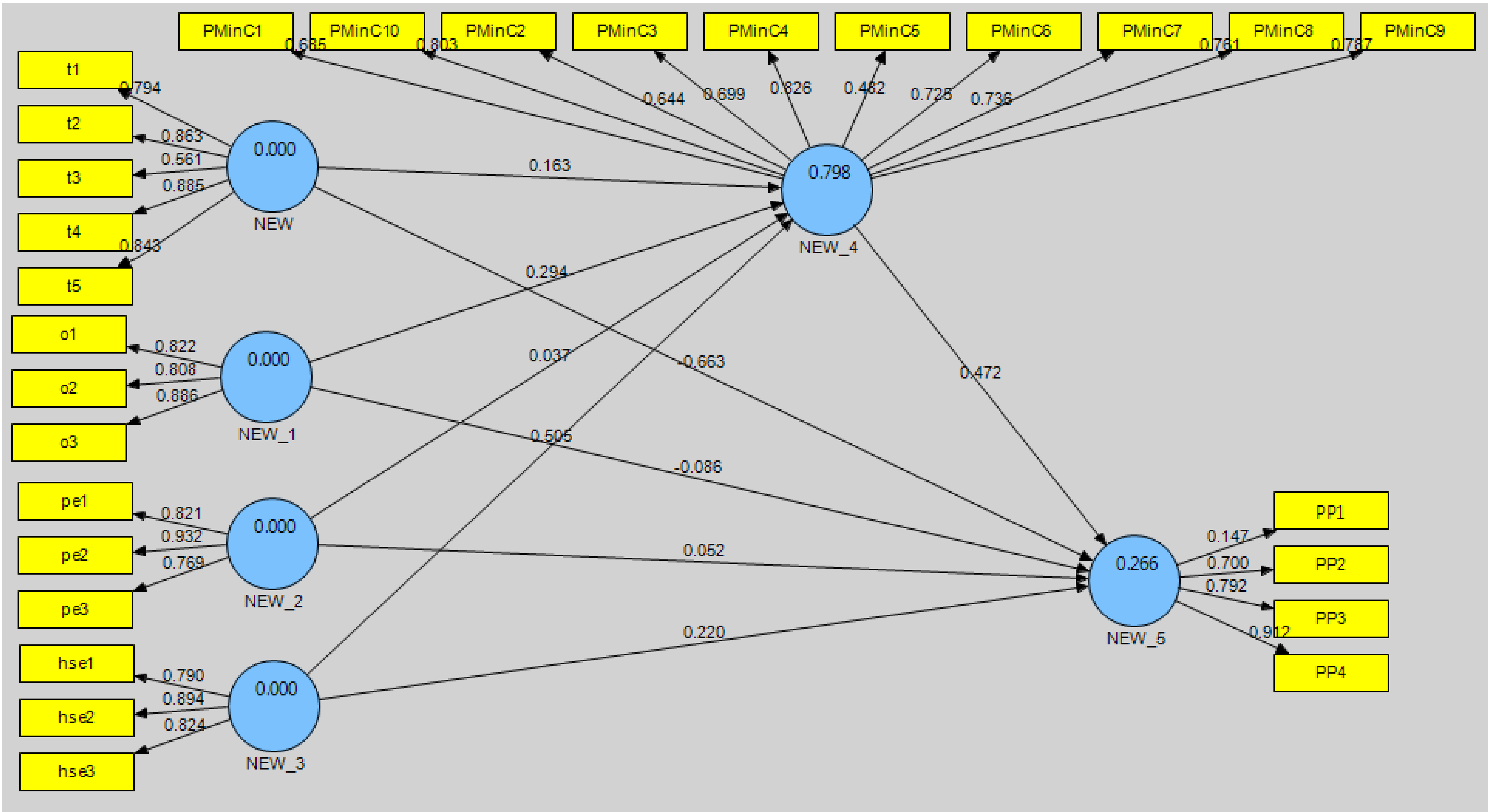
Organizational Category (NEW_1)

Project Environment Category (NEW_2)

Health, Safety, & Environment (HSE) Category (NEW_3)

Project Management in complexity (NEW_4)

Project Performance (NEW_5)


PMinC1
PMinC10
PMinC2
PMinC3
PMinC4
PMinC5
PMinC6
PMinC7
PMinC8
PMinC9
0.685
0.803
0.644
0.699
0.826
0.482
0.725
0.736
0.781
0.787
t1
t2
t3
t4
t5
0.794
0.863
0.561
0.885
0.843
0.000
NEW
0.163
0.798
NEW_4
0.294
o1
o2
o3
0.822
0.808
0.886
0.000
NEW_1
0.037
-0.663
0.472
0.505
-0.086
pe1
pe2
pe3
0.821
0.932
0.769
0.000
NEW_2
0.052
hse1
hse2
hse3
0.790
0.894
0.824
0.000
NEW_3
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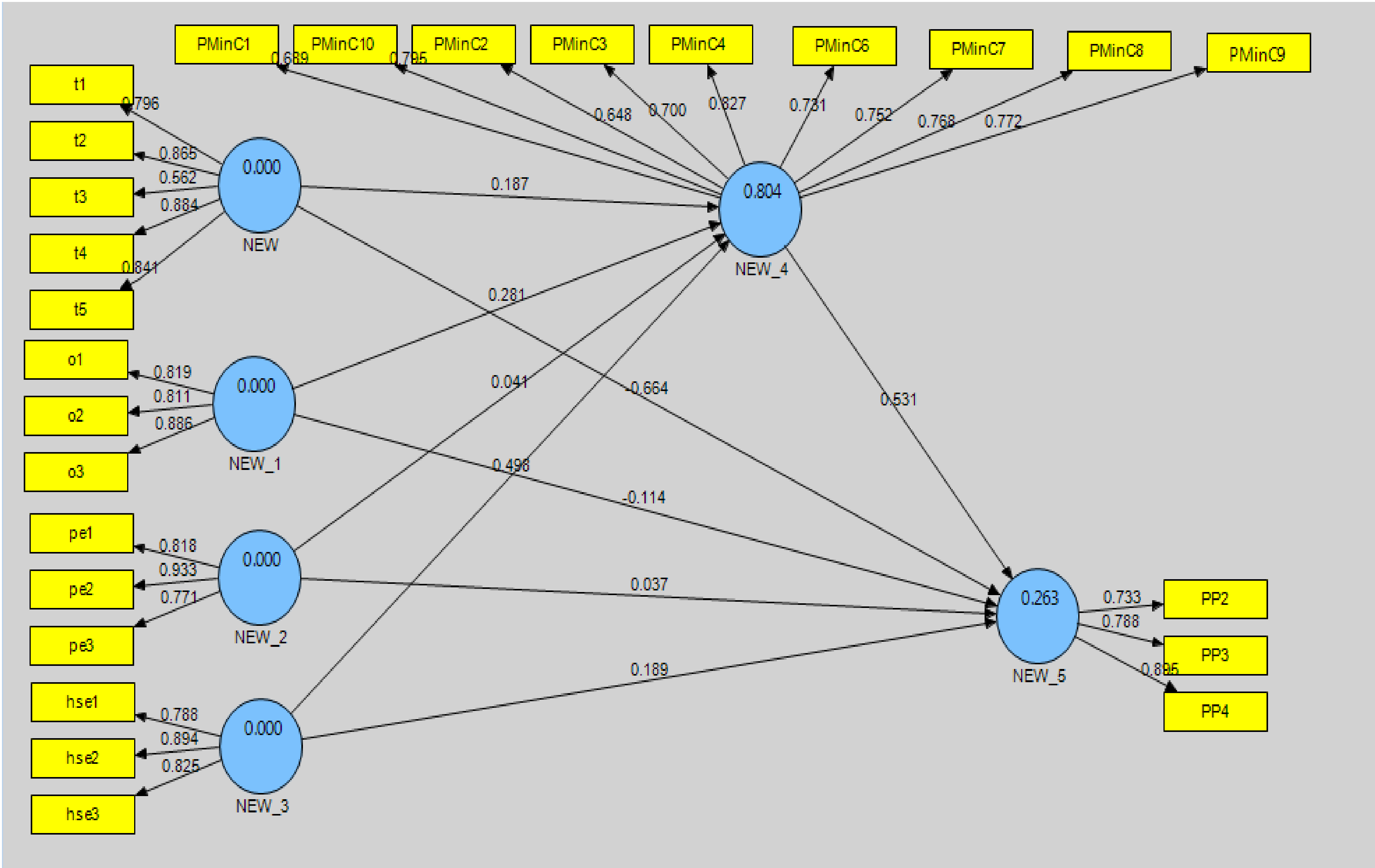
0.266
NEW_5
0.147
0.700
0.792
0.912
PP1
PP2
PP3
PP4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PMinC10
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PMinC3
PMinC4
PMinC6
PMinC7
PMinC8
PMinC9
t1
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t3
t4
t5
o1
o2
o3
pe1
pe2
pe3
hse1
hse2
hse3
PP2
PP3
PP4
0.000
NEW
0.000
NEW_1
0.000
NEW_2
0.000
NEW_3
0.804
NEW_4
0.263
NEW_5
0.796
0.865
0.562
0.884
0.841
0.819
0.811
0.886
0.818
0.933
0.771
0.788
0.894
0.825
0.689
0.795
0.648
0.700
0.827
0.731
0.752
0.768
0.772
0.187
0.281
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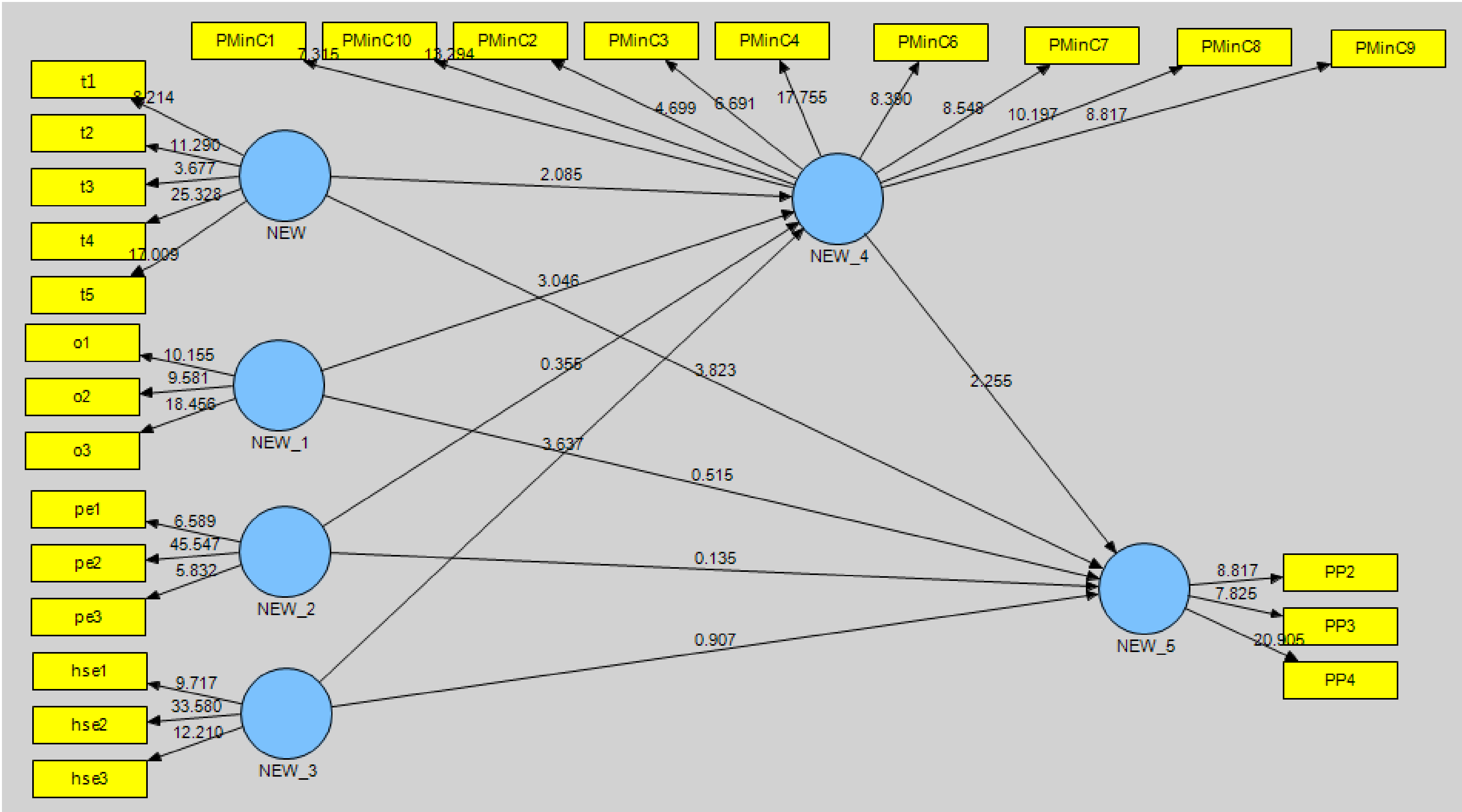
0.895


PMinC1
PMinC10
PMinC2
PMinC3
PMinC4
PMinC6
PMinC7
PMinC8
PMinC9
7.315
13.294
4.699
6.691
17.755
8.380
8.548
10.197
8.817
t1
t2
t3
t4
t5
8.214
11.290
3.677
25.328
17.009
NEW
2.085
NEW_4
3.046
o1
o2
o3
10.155
9.581
18.456
NEW_1
0.356
3.823
2.255
3.637
0.515
pe1
pe2
pe3
6.589
45.547
5.832
NEW_2
0.135
8.817
7.825
20.905
PP2
PP3
PP4
NEW_5
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hse1
hse2
hse3
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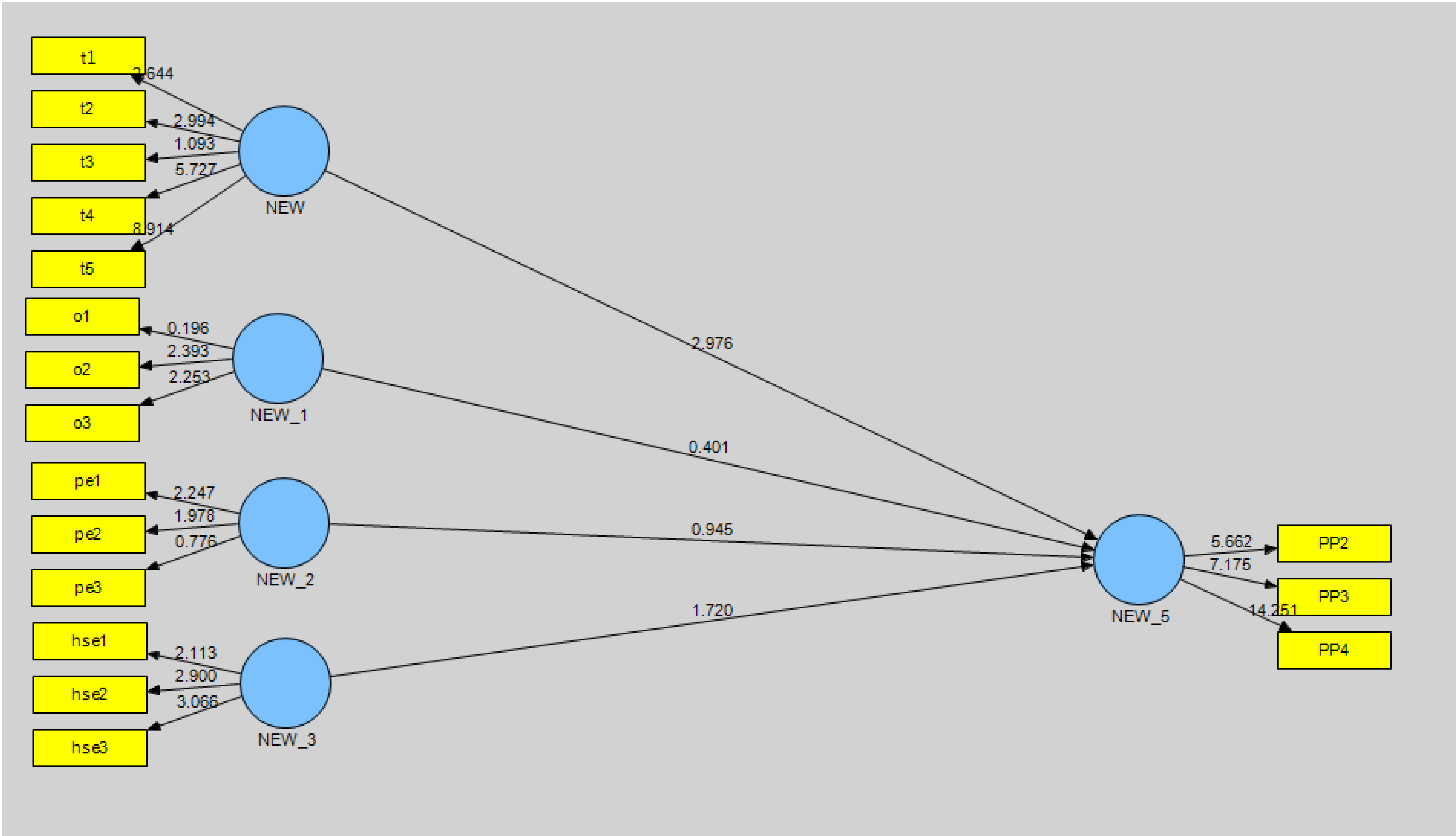
33.580
12.210
NEW_3



t1
t2
t3
t4
t5
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2.994
1.093
5.727
8.914
NEW
o1
o2
o3
0.196
2.393
2.253
NEW_1
pe1
pe2
pe3
2.247
1.978
0.776
NEW_2
hse1
hse2
hse3
2.113
2.900
3.066
NEW_3
2.976
0.401
0.945
1.720
NEW_5
5.662
7.175
14.251
PP2
PP3
PP4

Appendix 2: Research Data (Smart PLS Reports & Tables)

Partial Least Squares- Structural Equation Modeling (PLS-SEM)

Technical Category (NEW)

Organizational Category (NEW_1)

Project Environment Category (NEW_2)

Health, Safety, & Environment (HSE) Category (NEW_3)

Project Management in complexity (NEW_4)

Project Performance (NEW_5)

PLS Model

Quality Criteria

	AVE	Composite Reliability	R Square	Cronbachs Alpha
NEW	0.637458	0.895845		0.851105
NEW_1	0.704570	0.877199		0.789620
NEW_2	0.711557	0.880277		0.793702
NEW_3	0.700115	0.874754		0.785450
NEW_4	0.553912	0.917481	0.804475	0.898486
NEW_5	0.653110	0.848703	0.262967	0.733719

Cronbachs Alpha

	Cronbachs Alpha
NEW	0.851105
NEW_1	0.789620
NEW_2	0.793702
NEW_3	0.785450
NEW_4	0.898486
NEW_5	0.733719

Latent Variable Correlations

	NEW	NEW_1	NEW_2	NEW_3	NEW_4	NEW_5
NEW	1.000000					
NEW_1	0.777533	1.000000				
NEW_2	0.531863	0.669026	1.000000			
NEW_3	0.618623	0.687354	0.694433	1.000000		
NEW_4	0.735270	0.795940	0.674100	0.835081	1.000000	
NEW_5	-0.224745	-0.052129	0.097643	0.169863	0.135724	1.000000

R Square

	R Square
NEW	
NEW_1	
NEW_2	
NEW_3	
NEW_4	0.804475
NEW_5	0.262967

Cross Loadings

	NEW	NEW_1	NEW_2	NEW_3	NEW_4	NEW_5
PMinC1	0.493950	0.475868	0.439893	0.630285	0.688961	0.174032
PMinC10	0.509303	0.643880	0.464543	0.690429	0.795311	0.062314
PMinC2	0.511816	0.491412	0.337607	0.418453	0.647634	0.130238
PMinC3	0.579319	0.542479	0.468285	0.518595	0.699532	0.061482
PMinC4	0.592073	0.543668	0.477600	0.724830	0.827286	0.145875
PMinC6	0.529346	0.634832	0.602958	0.591773	0.730857	0.150204
PMinC7	0.494209	0.694939	0.614812	0.699324	0.751804	0.100167
PMinC8	0.635060	0.731970	0.520940	0.567100	0.768108	0.012338
PMinC9	0.590327	0.546932	0.550473	0.694586	0.771680	0.083487
PP2	-0.190030	-0.064234	0.014146	0.070418	0.086395	0.733199
PP3	-0.311638	-0.148738	-0.112172	-0.038640	-0.078268	0.788402
PP4	-0.093650	0.043670	0.254776	0.305971	0.253235	0.894523
hse1	0.423823	0.456760	0.552381	0.787527	0.646047	0.118733
hse2	0.615508	0.663061	0.585865	0.894184	0.805529	0.165805
hse3	0.495253	0.591559	0.612325	0.824973	0.625268	0.137682
o1	0.555078	0.818954	0.715357	0.649281	0.687219	0.095109
o2	0.665854	0.811270	0.435736	0.567069	0.613710	-0.111330
o3	0.736722	0.885926	0.525413	0.517452	0.699183	-0.118277
pe1	0.370836	0.454065	0.818267	0.542381	0.517693	0.251690
pe2	0.510338	0.692035	0.932985	0.675099	0.655336	0.031729
pe3	0.461048	0.529379	0.771135	0.528496	0.522444	-0.032913
t1	0.795905	0.494230	0.495577	0.488970	0.541317	-0.159979
t2	0.865144	0.660730	0.450709	0.569015	0.553464	-0.172036
t3	0.562208	0.403282	0.447920	0.521903	0.502898	-0.010948
t4	0.883866	0.744594	0.351933	0.505660	0.701661	-0.137517
t5	0.841459	0.731003	0.413606	0.414948	0.607818	-0.367691

AVE

	AVE
NEW	0.637458
NEW_1	0.704570
NEW_2	0.711557
NEW_3	0.700115
NEW_4	0.553912
NEW_5	0.653110

Composite Reliability

	Composite Reliability
NEW	0.895845
NEW_1	0.877199
NEW_2	0.880277
NEW_3	0.874754
NEW_4	0.917481
NEW_5	0.848703

Path Coefficients

	NEW	NEW_1	NEW_2	NEW_3	NEW_4	NEW_5
NEW					0.133099	-0.517787
NEW_1					0.126384	-0.056321
NEW_2					0.017259	0.017297
NEW_3					0.190366	0.079371
NEW_4						0.582891
NEW_5						

PLS Bootstrapping without mediate

Inner Model T-Statistic

	NEW	NEW_1	NEW_2	NEW_3	NEW_5
NEW					2.975876
NEW_1					0.401276
NEW_2					0.944930
NEW_3					1.720351
NEW_5					

Total Effects (Mean, STDEV, T-Values)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
NEW -> NEW_5	-0.499783	-0.514022	0.167945	0.167945	2.975876
NEW_1 -> NEW_5	-0.088180	0.074226	0.219748	0.219748	0.401276
NEW_2 -> NEW_5	0.247201	0.162916	0.261607	0.261607	0.944930
NEW_3 -> NEW_5	0.346635	0.244275	0.201491	0.201491	1.720351

Path Coefficients (Mean, STDEV, T-Values)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
NEW -> NEW_5	-0.499783	-0.514022	0.167945	0.167945	2.975876
NEW_1 -> NEW_5	-0.088180	0.074226	0.219748	0.219748	0.401276
NEW_2 -> NEW_5	0.247201	0.162916	0.261607	0.261607	0.944930
NEW_3 -> NEW_5	0.346635	0.244275	0.201491	0.201491	1.720351

PLS Bootstrapping

Inner Model T-Statistic

	NEW	NEW_1	NEW_2	NEW_3	NEW_4	NEW_5
NEW					2.085111	3.823363
NEW_1					3.046465	0.515086
NEW_2					0.355074	0.135124
NEW_3					3.637420	0.907245
NEW_4						2.254976
NEW_5						

Total Effects (Mean, STDEV, T-Values)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
NEW -> NEW_4	0.187168	0.195920	0.089764	0.089764	2.085111
NEW -> NEW_5	-0.564154	-0.538368	0.142828	0.142828	3.949895
NEW_1 -> NEW_4	0.280821	0.273654	0.092179	0.092179	3.046465
NEW_1 -> NEW_5	0.035128	0.130998	0.204303	0.204303	0.171939
NEW_2 -> NEW_4	0.040974	0.093512	0.115396	0.115396	0.355074
NEW_2 -> NEW_5	0.059192	-0.040805	0.264350	0.264350	0.223914
NEW_3 -> NEW_4	0.497818	0.458042	0.136860	0.136860	3.637420
NEW_3 -> NEW_5	0.453611	0.419727	0.164198	0.164198	2.762582
NEW_4 -> NEW_5	0.531220	0.561171	0.235577	0.235577	2.254976

Path Coefficients (Mean, STDEV, T-Values)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)	T Statistics (|O/STERR|)
NEW -> NEW_4	0.187168	0.195920	0.089764	0.089764	2.085111
NEW -> NEW_5	-0.663581	-0.646478	0.173560	0.173560	3.823363
NEW_1 -> NEW_4	0.280821	0.273654	0.092179	0.092179	3.046465
NEW_1 -> NEW_5	-0.114050	-0.022433	0.221420	0.221420	0.515086
NEW_2 -> NEW_4	0.040974	0.093512	0.115396	0.115396	0.355074
NEW_2 -> NEW_5	0.037425	-0.092932	0.276971	0.276971	0.135124
NEW_3 -> NEW_4	0.497818	0.458042	0.136860	0.136860	3.637420
NEW_3 -> NEW_5	0.189161	0.162841	0.208500	0.208500	0.907245
NEW_4 -> NEW_5	0.531220	0.561171	0.235577	0.235577	2.254976

Total Effects (Mean, STDEV, T-Values)

	Original Sample (O)	Sample Mean (M)	Standard Deviation (STDEV)	Standard Error (STERR)
NEW -> NEW_4	0.187168	0.195920	0.089764	0.089764
NEW -> NEW_5	-0.564154	-0.538368	0.142828	0.142828
NEW_1 -> NEW_4	0.280821	0.273654	0.092179	0.092179
NEW_1 -> NEW_5	0.035128	0.130998	0.204303	0.204303
NEW_2 -> NEW_4	0.040974	0.093512	0.115396	0.115396
NEW_2 -> NEW_5	0.059192	-0.040805	0.264350	0.264350
NEW_3 -> NEW_4	0.497818	0.458042	0.136860	0.136860
NEW_3 -> NEW_5	0.453611	0.419727	0.164198	0.164198
NEW_4 -> NEW_5	0.531220	0.561171	0.235577	0.235577

	T Statistics (|O/STERR|)
NEW -> NEW_4	2.085111
NEW -> NEW_5	3.949895
NEW_1 -> NEW_4	3.046465
NEW_1 -> NEW_5	0.171939
NEW_2 -> NEW_4	0.355074
NEW_2 -> NEW_5	0.223914
NEW_3 -> NEW_4	3.637420
NEW_3 -> NEW_5	2.762582
NEW_4 -> NEW_5	2.254976