Improving Risk Management in Megaprojects

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Dedication

This thesis is dedicated to

My kind parents who never stop giving of themselves in countless ways.

My beloved wife, Sura, who joined me through this journey with a lot of love, endless support and patience.

My lovely children, Mina and Mohammed, the signs and wonders of this universe.

My brother and sister for their love, encouragement and support.

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Abstract

Studies suggest that, despite the recent improvements in project risk management, 50-70% of Megaprojects do not meet cost, time or performance objectives, a much higher proportion than that for conventional projects.

A critical appraisal of conventional risk management approaches revealed that many of the conditions for the successful application of these approaches were not satisfied in Megaprojects; in particular, problems arose from incomplete, insufficient and inaccurate data. These constraints severely limit the capability of conventional approaches to manage risks in Megaprojects, to the extent that they might not produce meaningful and realistic results.

Accordingly, this research aims to improve the Megaproject delivery performance by introducing a better way of risk management beyond the conventional approaches. Thus, Adapted Grounded Theory was conducted to collect and analyse empirical data from semi-structured interviews with Megaproject experts. Drawing on the analysis of empirical findings, a new risk management approach in Megaprojects was grounded and developed.

The new approach is unique in that it comprises for the first time a combination of practical mitigation measures that could be applied systematically and consistently to manage and mitigate Megaproject Common Risks (MCRs) collectively. Until now, there has been no such comprehensive approach; this research study is the first to attempt to do this.

The contents, structure, viability and practicality of the proposed approach were tested and validated by another set of Megaproject experts through the Delphi method. The Delphi results confirm that the proposed approach has the potential to drive significant improvements to the Megaproject delivery performance that may not otherwise be achievable by conventional approaches.

Accordingly, it can be concluded that the current research study succeeds in filling the knowledge gap by introducing a paradigm shift from conventional risk management into a systematic risk management approach. The research study provides an original contribution theoretically, methodologically and practically, which adds to the body of knowledge of risk management and to Megaprojects.

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List of Abbreviations

AGT	Adapted Grounded Theory
Brexit	British Exit
BS	British Standard
CMMs	Critical Mitigation Measures
CNS	Comprehensive National Strategy
COP	Code of Practice
EU	European Union
GMPP	Government Major Projects Portfolio
HM	Her Majesty
IPA	Infrastructure and Projects Authority
ISO	International Organisation for Standardisation
MCRs	Megaproject Common Risks
MRs	Megaproject Risks
NAO	National Audit Office
NFC	New Form of Contract
NIC	National Infrastructure Commission
NPVs	Net Present Values
PFI	Private Finance Initiative
PMO	Project Management Office
PPPs	Public Private Partnerships
RPC	Regulatory Policy Committee
SPV	Special Purpose Vehicle
STEEP	Social, Technical, Economic, Environmental and Political

Chapter 1 Introduction

1.1 Introduction

This chapter introduces the research presented in this thesis. It begins by explaining the research background, followed by the articulation of the research problem. It then clearly outlines the aim and objectives of this research study. The chapter then briefly describes the research methodology adopted to achieve the research aim and objectives. This is followed by a separate section on the research originality. Finally, the chapter outlines the structure of this thesis and briefly describes the contents of the individual sections.

1.2 Research Background

Megaprojects are widely accepted as major tools to satisfy the increasing demand for public needs. They are temporary endeavours characterised by large investment, complexity and long-lasting duration with significant direct and indirect impacts on the global aspects including Social, Technical, Environmental, Economic and Political (STEEP). Megaprojects have been attracting more attention in recent years and have become a popular research topic in the area of project management [1]. Megaproject examples include high-speed railway systems, airports and seaports, motorways, the Olympics, dams, wind farms, offshore oil and gas extraction, and communications technology (ICT) systems.

Although an increasing number of Megaproject developments are being undertaken worldwide, their track record in delivery performance is often disappointing [2]. This poor delivery performance has been considered problematic in relation to excessive delay, massive cost overrun, and not achieving the desired outcomes once in operation. Megaproject underperformance has been investigated by both academics and practitioners in the field.

Cantarelli and Flyvbjerg [3] examined the cost overrun in transportation infrastructure Megaprojects (rail, fixed links and road) in Europe, North America and other geographical areas. The authors showed that the average cost overrun in Europe (181 projects) was 26%, while in North America (61 projects) it was 24%, and, finally, in other geographical areas (16 projects) it was 65%. Merrow [4] investigated the delivery performance of oil and gas Megaprojects and found that up to 78% of the projects suffered significant cost overruns at an average of 33%. Love *et al.* [5] found the mean cost overruns of 13.28% and schedule overruns of 8.91% based on their analysis of 58 transportation infrastructure projects. A recent paper by Smith and Jobling [6] has reported that up to two-thirds of Megaprojects suffer cost and time overrun. The underperformance of Megaprojects is also reported by many other similar studies [7-18].

In the UK context, the track record in delivering Megaprojects is also disappointing [19]. A recent report by the National Audit Office (NAO) has recognised that, despite the improvements in managing Megaprojects and Programmes in some departments, project failures have regularly been reported in addition to the considerable difficulties in ongoing projects [19]. The Infrastructure and Projects Authority (IPA) annual report shows that the government is continuing to struggle with the implementation of existing projects [20]. According to a recent NAO report on delivering Megaprojects in government, the IPA has rated around 35% of Megaprojects scheduled to finish by the end of the financial year 2019-20 as red or amber-red, meaning that successful delivery is unachievable or in doubt unless action is taken, as shown in Figure 2.1 [19]. The Edinburgh Tram Network Project is a recent example of a Megaproject that experienced poor delivery performance.

The above figures on cost and time overrun underline that the poor delivery performance of Megaprojects is getting worse. This is confirmed by Locatelli [21], who argues that the problem of cost overruns in Megaprojects is systematic, with no relevant improvement over time. Given the diversity and number of stakeholders, such poor delivery performance represents a major concern for Megaproject clients, to the extent that it can bring serious consequences to the commercial viability of the project. A small percentage of cost overrun on a Megaproject with a budget of multi-billions of pounds can result in it going millions of pounds over-budget, leaving clients dissatisfied and taxpayers often out of pocket. To the organisation, the poor delivery performance of a Megaproject often leads to significant financial losses in terms of opportunities, competitions, productivity and reputations [22]. Due to the scale of impact of Megaprojects on global aspects, the poor delivery performance can also jeopardise the economic viability of the area in which they are built [23]. The devastating consequences of not managing risks properly could be sudden bankruptcy of companies or government upheaval [24].

Many causes behind the poor performance of Megaprojects have been well recognised and documented in the literature. Flyvbjerg's studies [10, 11, 25-29] showed that Megaprojects' poor performance could be attributed to four key factors: technical, psychological, deliberate underestimation of cost and poor financing/contract management. According to Merrow [30], the top eight factors leading to the poor performance of Megaprojects are greed, schedule pressure to reduce construction time and increase the Net Present Value, poor bidding phase, poor quality "Front End Loading" due to the reduction in the upfront cost, unrealistic cost estimations, poor risk allocation, excessive pressure on project manager and 'blame culture'.

Love *et al.* [31] in their recent publication have recognised that two predominant schools of thought have emerged around the poor cost performance in Megaprojects: 'evolution theorists' and 'psycho strategists'. The evolution theorists argue that the overrun is caused by scope changes over the whole Megaproject life cycle, whereas the psycho strategists attribute overrun to deception, planning fallacy and unjustifiable optimism in the setting of the initial cost. Further, Love *et al.* [31] argued that overrun seldom occurs as a result of a stand-alone cause; instead, the inadequate investigation of the interdependencies among those causes is another attribute to cost and time overrun.

In the UK context, the NAO indicated that there are many other reasons why Megaprojects fail to meet expectations, including poor project management and the impact of global factors (STEEP) which are beyond the control of those responsible for delivering the project [32]. Another recent NAO report has identified five recurring issues across Departments of the UK Government that were contributing to poor performance in Megaprojects [19]. The five issues are the absence of portfolio management at the departmental level and the government level, the lack of clear and consistent data to measure performance, lack of early planning, lack of capacity and capability to undertake the increasing number of Megaprojects, and lastly the lack of clear accountability for the leadership of a project [19]. These five issues severely undermine the probability of a project's success, often leading to significant cost overruns, excessive delays in completion and failure to deliver the benefits [19].

It can be seen from the above studies that the issues and factors affecting the poor delivery performance of Megaprojects have received considerable critical attention by both academics and practitioners and are well appreciated in the literature. However, there are some matters that need to be investigated and addressed thoroughly in order to improve risk management in Megaprojects. A general conclusion drawn from the above studies is the inherent risk in Megaprojects is the dominant reason behind the poor delivery performance of these projects [2, 32]. The above studies also underline that there is little evidence of an in-depth investigation of what are the common risks behind the poor delivery performance of Megaprojects. Furthermore, many studies and research projects to date tend to develop and recommend generic lists of risks to Megaprojects without considering the scale and complexity of these projects. A possible explanation behind this is that no common risk terminology exists across all Megaprojects [33-36]. Therefore, Megaproject Common Risks (MCRs), their definitions and elements need to be investigated in theory and practice in order to manage and/or mitigate them better.

Even though research and developments in project risk management over the last 50 years have resulted in significant improvements in the delivery of conventional projects, the same is not true of Megaprojects [6]. A detailed review of conventional approaches to risk management revealed that many of the conditions for the successful application of these approaches were not satisfied in Megaprojects; in particular, problems arose from incomplete, insufficient and inaccurate data [37]. These constraints severely limit the capability of conventional methods to manage risks in Megaprojects, to the extent that these methods could not produce meaningful and realistic results [38]. Moreover, conventional approaches tend to rely on best practices, which may be applicable only in certain circumstances [6]. While such approaches can work in conventional projects with a limited number of parameters, they do not apply to Megaprojects.

Alternative approaches to conventional methods have been advanced to help in the management of risks. Some of these have a radical change thinking in managing risks in Megaprojects; others remain in the classical school with modest improvements. For example, Rolstadås *et al.* [39] developed an executive approach with a new way of thinking about managing risks in major capital projects. The ICE and the Institute and Faculty of Actuaries published the third edition of Risk Analysis and Management for Projects (RAMP) as a strategic framework for managing project risk and its financial implications [40]. Agile project management methodology has been used in Megaprojects, which promotes a process to encourage development iterations, teamwork, stakeholder involvement, objective metrics and effective controls [41].

Despite the potential of the above approaches, it is painfully apparent that the delivery performance of Megaprojects is still without noticeable improvements [6]. The environment in which most Megaprojects operate is very complex, turbulent and uncertain, and conventional project management is not well suited to such conditions [42, 43]. This is supported by Dimitriou *et al.* [44], who advocated for a dramatic change of mindset concerning the way in which Megaprojects are positioned, framed, planned and ultimately judged. Thamhain [24] also suggested that managing risks effectively in complex systems like Megaproject requires project management methodologies that go beyond conventional approaches. Callegari *et al.* [7] also suggested that Megaproject practitioners need to go beyond traditional risk management in order to deal with the extreme uncertainty surrounding this sort of project.

The above argument underlines that there is an open debate on risk management in Megaprojects and that there is room for further improvements [45]. It also raises three research questions: Is there a better way to improve risk management in Megaprojects beyond the existing conventional approaches? What are MCRs? Is there a better way to think about MCRs? Accordingly, these questions motivate the current research study, which seeks to revisit the problem of poor performance delivery of Megaprojects to prompt and offer fresh thinking about risk management in Megaprojects [31].

1.3 Research Problem

The previous section has laid down the foundation for the current research study and has revealed three crucial issues. First, there is a need to address the significant problem of risk management in Megaprojects as a fundamental part of project management. This because the failure costs for this sort of project are particularly high due to their scale and size. Therefore, it is very important to improve the current situation because the associated financial and social impacts could be disastrous. Second, the existing conventional risk management approaches have not been adequate for handling the poor delivery performance of Megaprojects. In fact, the 'scaling-up' of conventional approaches to managing Megaprojects is not delivering noticeable improvements, to the extent that these are ineffective in managing and mitigating Megaproject risks. Third, although all Megaproject Risks (MRs) are important, MCRs seem to pose systemic and continuous threats to Megaproject success since they occur in all Megaprojects and only in Megaprojects. These MCRs are not defined and/or identified systematically; hence, they need special attention and further research. This means the definitions and elements of MCRs need to be investigated in theory and practice in order to manage and/or mitigate them better.

Although extensive research has been carried out on Megaprojects, there is a dearth of studies that have attempted to investigate MRs and differentiate them from risks associated with conventional projects. In actual fact, the focus on MCRs, which are strongly linked to poor performance in Megaprojects, is not well appreciated in the literature. Traditional Megaprojects literature tends to identify risks from a general perspective without considering how these risks are common to all Megaprojects [23, 46, 47]. For example, Patanakul [47] identified common problems in managing IS/IT Megaprojects in the public-sector only, whereas Megaprojects can also be partially or fully funded by the private sector. Lam [23] provided a sectoral review of risks associated with infrastructure Megaprojects without indicating to what extent they are common to all Megaprojects. Therefore, the current research seeks to bridge this gap by identifying, defining, and managing MCRs in a better way. To address and fill this gap, three research questions were formulated, Is there a better way to improve risk management in

Megaprojects beyond the existing conventional approaches? What are MCRs? Is there a better way to think about MCRs?

1.4 Aim and Objectives of the Research

The aim of this research is to improve risk management of Megaprojects, hence improve their delivery performance.

To fulfil the above aim, the following objectives are set:

1. Understand the nature of Megaproject Risks.
2. Critical appraisal of risk management weaknesses in Megaprojects.
3. Identify Megaproject Common Risks (MCRs).
4. Develop a new approach to manage and/or mitigate Megaproject Common Risks (MCRs) collectively to suit the UK context.

1.5 Research Methodology

Although the research methodology is presented and discussed in Chapter 5, and the flow-chart details are depicted in Figure 5.2, the current section briefly outlines the adopted research methodology process, which consists of three phases: pre-fieldwork phase, fieldwork phase, and post fieldwork phase.

The pre-fieldwork phase starts with a literature review of the Megaproject and Risk Management areas, where the outcomes help to highlight the knowledge gap, form the problem statement, and articulate the research aim and objectives. A systematic literature review with content analysis was also applied in this phase to identify a comprehensive list of 38 MRs. This comprehensive list was used as the main source to identify and define a unique set of five MCRs systematically.

The pre-fieldwork phase also involves the derivation of the theoretical constructs of the proposed approach of risk management to Megaprojects. The derivation process involves two stages. The first stage involves identifying a comprehensive list of ten recommended mitigation measures for Megaprojects. The second stage involves evaluating, justifying and selecting four Critical Mitigation Measures (CMMs) to Megaprojects. These two stages were then followed by synthesising the theoretical concepts that underpin both MCRs and CMMs, then considered as the fundamental elements of the approach to address the research problem, which in turn is used as the main vehicle for collecting empirical data in the fieldwork study phase.

In the fieldwork phase, Adapted Grounded Theory (AGT) has been adopted and justified to collect data, where interview questions were structured, designed and formulated in accordance with the four CMMs proposals. The collected data was analysed by using a systematic coding procedure in the post-fieldwork phase.

Once all data was analysed, the empirical findings were discussed and compared with the literature review to design and develop a new approach to the risk management of Megaprojects. The approach was then validated using the Delphi technique.

Once the Delphi results were analysed and reflected, the implications of the research findings on theory and practice were also provided and discussed. Based on this discussion, conclusions, implications for theory and practice, and recommendations for future research were derived.

1.6 Research Originality

The current research study introduces an original approach to risk management in Megaprojects beyond conventional approaches. As far as can be ascertained, the proposed approach is unique in that it comprises for the first time a combination of practical mitigation measures that could be applied to manage and mitigate MCRs, affecting cost and time performance of all Megaprojects and only Megaprojects. The four mitigation measures proposals are: legislating and enabling a specific Act of Parliament (ACT) for Megaprojects, developing a Project Management Office (PMO) for Megaprojects at the national level, developing a specific Code of Practice (COP) for planning and delivering Megaprojects, and developing a New Form of Contract (NFC) for Megaprojects. Until now, there has been no such comprehensive approach; this research study is the first to attempt to do this.

1.7 Structure of the Thesis

This thesis consists of nine chapters, the details of which are presented as follows:

Chapter 1 Introduction: This chapter serves as an introduction to the research and comprises the introduction to the subject, research background, research problem, research aim and objectives, research methodology, research originality and the structure of the thesis.

Chapter 2 Megaprojects and Risks: This chapter provides a clear definition of Megaprojects by discussing their unique characteristics that distinguish them from conventional construction projects. Accordingly, it discusses and clarifies the differences between MRs and conventional risks. Then it introduces a comprehensive list of MRs by using a systematic literature review with content analysis method.

Chapter 3 Critical Appraisal of Risk Management in Megaprojects: This chapter reviews risk management theory, process, practice and research, and builds the theoretical foundation for this research study. It also provides a critical appraisal of risk management weaknesses in Megaprojects followed by a review of the related studies to highlight the knowledge gap, and hence reflect where the study stands in a wider context. Finally, it provides a critical discussion that justifies the need for fresh thinking about risk management in Megaprojects.

Chapter 4 Derivation of Theoretical Constructs of the Proposed Approach: This chapter is built upon the theoretical foundation provided in chapters 2 and 3. It aims to present and justify the synthesis of theoretical concepts and fundamental principles that underpin both MCRs and CMMs as fundamental elements for the development of the proposed approach to risk management for Megaprojects.

Chapter 5 Research Methodology: This chapter discusses the adopted research methodology. It discusses and justifies the adopted research reasoning, approach, method and data collection techniques to achieve the research aim and objectives. It also describes in detail the research process adopted to apply this methodology. It further provides a discussion on the fieldwork study activities to collect and analyse the data through AGT followed by a discussion and justification of the research validation through the Delphi technique.

Chapter 6 Research Findings: This chapter provides a presentation and structure of the data collected from the AGT research method as the empirical research findings. The data is collected from the AGT interviews with Megaproject experts, where some of their quotations are also included to provide supporting verbal evidence for each finding.

Chapter 7 Development and Validation of the Proposed Approach: This chapter discusses the development process of a new approach to risk management in Megaprojects based on the research findings. It describes and discusses the features, objectives, structures and elements of the proposed approach. It also discusses the validation process for the proposed approach using the Delphi technique and presents the validation results.

Chapter 8 Discussion: This chapter discusses the main research findings and their implications for theory and practice. It also provides a critical discussion of the proposed approach in the UK context. It also discusses and explains the implementation of the research findings, i.e. the proposed approach, in managing and mitigating MCRs collectively.

Chapter 9 Conclusions, Recommendations and Implications: This chapter presents the main conclusions drawn from the research findings. It also explains how the aim and objectives were achieved and reflects upon the overall research contribution. The chapter then discusses the limitations of the research and provides recommendations for further work.

Chapter 2 Megaprojects and Risks

2.1 Introduction

This chapter aims to provide a general picture of Megaprojects and the associated risks contributing to poor delivery performance. The chapter consists of six sections, including this introduction. Section 2.2 defines Megaprojects by presenting and discussing the key characteristics that distinguish Megaprojects from other conventional construction projects. Section 2.3 reviews the delivery performance of Megaprojects, which is disappointing in terms of cost and time overrun in both global and UK contexts. Section 2.4 investigates the nature of MRs by distinguishing them from risks associated with conventional construction projects. Section 2.5 identifies a comprehensive list of MRs by using a systematic literature review with content analysis method. Lastly, Section 2.6 provides a summary of the chapter.

2.2 Megaproject Definition

Different terms have been used in the literature to describe Megaprojects. Irimia-Diéguez *et al.* [48] used different terms such as "megaproject", "mega project", "big project", "complex project" and "large project" to investigate risk management in Megaprojects. The terms "major project" or "major program(me)" have frequently been used to define large-scale public projects in developed countries such as the USA and UK [49], whereas it has been observed that the term "giant projects" is rarely used to describe a similar type of project [50]. Authors like Miller and Lessard [51], Lee *et al.* [52], Mousavi *et al.* [53] have used the term "large engineering projects" to describe Megaprojects. In the current research study, the terms "Megaprojects" is adopted because it is widely accepted in the literature.

The definition and features of Megaprojects have been extensively discussed in the literature [2, 29, 54-56]. Haidar and Ellis [57] defined Megaprojects as unique construction projects characterised with a high level of complexity, vast size, expensive cost, and long time frame compared with conventional construction projects. Similarly, Fiori and Kovaka [54] defined Megaprojects as construction projects that have five common elements: cost, complexity, risk, ideals and visibility that are magnified beyond the level of a “standard” or “typical” construction project. Sykes [58] identified nine characteristics of Megaprojects: large size and multiple owners; public opposition to the expected social, economic, political and environmental impacts; developing time takes a decade or more; located in remote and/or inhospitable areas; potential to destabilise markets; unique risk, especially when project spans economic cycles; financing difficulties; lack of experience; and career risks, because most of the undertakings do not advance past the planning stage and therefore pose an unpopular career course for senior managers. Flyvbjerg [27], Flyvbjerg [59], and Flyvbjerg [26] outlined several characteristics to distinguish Megaprojects by considering them as inherently risky, multi-actor decision-making processes, with inadequate scope definition, inadequate contingencies, and unique design. Gellert and Lynch [60] indicated that there are four general categories of Megaprojects: infrastructure projects such as transportation, energy and water management; extraction projects such as resource extraction, like oil and gas; production projects such as industrial projects; and consumption projects such as massive entertainment and shopping centres.

In this research study, any project demonstrating the majority of the attributes outlined by Sykes [58], Flyvbjerg [14], and Gellert and Lynch [60] is considered to be a Megaproject. The above definitions make explicit the contrast between Megaprojects and conventional projects as the former have a common set of characteristics that differentiate them from conventional projects. The key differences between Megaprojects and conventional projects can be summarised in Table 2.1.

Table 2.1 underlines that Megaprojects are not just a scaled-up and magnified version of conventional construction projects. Instead, Megaprojects are completely different since they involve a unique set of risks and elements that cannot exist in other conventional construction projects [41]. This underlines that applying classical risk management approaches in Megaprojects context need to be with caution as it can be misleading [6, 61, 62]. Therefore, it can be argued that Megaprojects may require another approach of risk management beyond the conventional approaches.

Table 2-1 Comparison between Megaprojects and Conventional Projects

Aspect	Conventional Projects	Megaprojects
Scale	The size is limited, requiring a small area of land and purchase of a small number of businesses and dwellings.	The size of Megaprojects is unlimited, and a Megaproject can also be seen as a combination of different, smaller projects [6, 28].
Cost	Multiple millions of pounds	Multiple billions of pounds [43].
Finance	Short-term financial plan with no need for a dedicated application for the governmental fund.	The scale of Megaprojects necessitates a complex financial and commercial structure [9].
Complexity	Low level of complexity.	High level of complexity [51].
Interfaces	Most project developers have well-known expertise from previous similar projects.	Requiring unprecedented integration of expertise and efforts [63].
Life cycle	Short-term life cycle.	Megaprojects have a very long life cycle lasting for decades [64].
Innovation	Proven and well understood.	Ground-breaking innovation and unprecedented engineering [65].
Contract	Well-defined and straightforward contractual arrangement.	Megaprojects, by definition, are incomplete contracts leading to high additional costs [6].
Impact	The impact of global aspects is less on project outputs due to the small-scale features.	The impact of global aspects on Megaprojects outputs and outcome is considerable [66].
Stakeholders	Known external stakeholders with predictable behaviours and requirements [67].	Megaprojects involve many stakeholders within a multicultural environment and who are geographically diverse [68].
Uncertainty	The level of uncertainty is relatively low because of the frequent repetition of similar types of projects.	The level of uncertainty is very high as a result of the features of Megaprojects, which make changes in global aspects (STEEP) inevitable [47].

2.3 Megaproject Performance

Although an increasing number of Megaproject developments are being undertaken worldwide, the track record relating to Megaproject delivery performance is often disappointing [2]. This poor delivery performance has been considered problematic in terms of excessive delay, massive cost overrun and not achieving the desired outcomes once in operation. Megaprojects underperformance is investigated by many authors who contributed to risk management in Megaprojects knowledge. For example, Flyvbjerg *et al.* [28] conducted a study on more than 250 highway and rail projects that worth around

£90 billion in 20 countries, and they found that 90% of transportation infrastructure Megaprojects are underperformance in terms of schedule and budgets. Merrow [4] investigated the delivery performance of oil and gas Megaprojects and found that up to 78% of the projects suffer significant cost overruns at an average of 33%. Olaniran *et al.* [14] reported that around 64% of ongoing Megaprojects globally are facing cost overruns. There are many other studies reached the same conclusion that Megaprojects are systematically suffering from cost and time overrun [7-18].

In the UK context, the track record in delivering Megaprojects is also disappointing [19]. A recent report of the NAO has recognised that, despite the improvements in managing Megaprojects and Programmes in some Departments, project failures had been reported regularly in addition to the considerable difficulties in ongoing projects [19]. The Infrastructure and Projects Authority (IPA) annual report in 2017 has shown that the government is on-going to struggle with the implementation of existing projects [20]. According to a recent NAO report on government delivery of Megaprojects, the IPA has rated around 35% of Megaprojects scheduled to finish by the end of the financial year 2019-20 as red or amber-red, as shown in Figure 2.1 [19]. The amber-red colour in Figure 2.1 indicates that the successful delivery of a project is unachievable or in doubt unless action is taken [19]. The other colour indicators of delivery confidence ratings shown in Figure 2.1 indicate a more satisfactory performance of Megaprojects. However, overall, Figure 2.1 underlines that the poor delivery performance of Megaprojects is not improving.

Given the scale of complexity and the involvement of many stakeholders in Megaprojects, a poor delivery performance represents a major concern for the client and for those who are funding such undertakings to the extent it can bring serious consequences to the commercial viability of the project. To the organisation, the poor delivery performance of Megaprojects often leads to significant financial losses in terms of opportunities, competitions, productivity, and reputations [22]. In fact, and because Megaprojects have a significant impact to the global aspects including Social, Economic, and Environmental, the poor delivery performance can also jeopardise the economic viability of the area where Megaprojects are built-in [23]. Sometimes the devastating consequences of not managing risks properly could be sudden bankruptcy of companies or government upheaval [24]. For instance, if a multi-billion Megaproject was facing 10-40% cost overrun, the results could be catastrophic in nature that could bankrupt some governments while some financial institutions cannot remain in business.

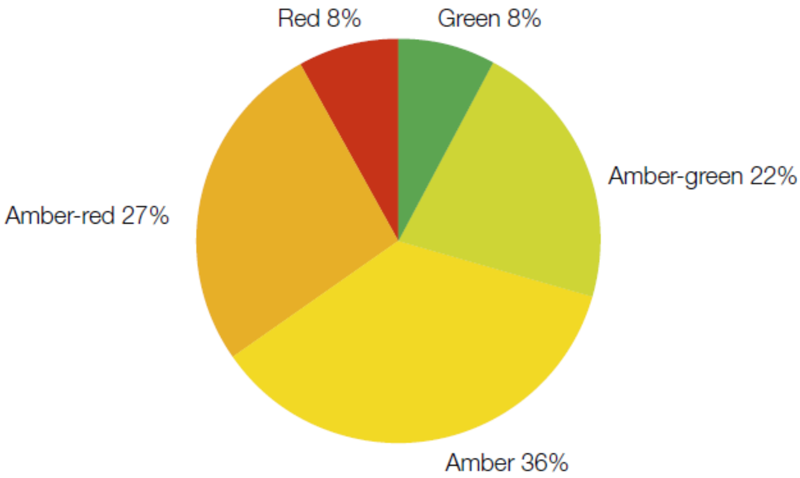

Figure 2-1 Delivery Confidence Rating of 106 Megaprojects Scheduled to Finish Between 2015-16 and 2019-20 in the UK [19]

The literature provides a number of explanations for the disappointing delivery performance of Megaprojects. Researchers such as Flyvbjerg *et al.* [28] argued that poor performance in Megaprojects is due to nine significant factors: political bias, unrealistic original cost estimates, changes in design, low contingencies, underestimation of geological risk, quantity and price undervaluation, political risk and expropriation, technological risk, and underestimation of the length and cost of delays. Other researchers such as Merrow [30] argued that the poor delivery performance of Megaprojects is due to a failure to suitably plan the project at the very early stages in its life cycle. Whereas, Williams and Samset [42] argued that Megaprojects suffer from the lack of a structured and rigorous decision-making process, which negatively affects the delivery performance.

A recent NAO report on government delivery of Megaprojects also has provided explanations for the poor delivery records of Megaprojects [19]. This NAO report identified five recurring issues across the Departments of the UK Government that were contributing to the poor delivery performance: lack of portfolio management at both departmental and government level; lack of clear, consistent data with which to measure performance; poor early planning; lack of capacity and capability to undertake a growing number of projects; and a lack of clear accountability for leadership of a project [19].

A general conclusion drawn from the above studies is the inherent MRs are the dominant reason behind the poor delivery performance of Megaprojects [2, 32]. There is extensive evidence that these risks are proving somewhat intractable, often leading to considerable cost overruns, delays in completion and failure to deliver Megaprojects objectives within the desired outcomes [2, 32]. As a result, many Megaprojects fail to achieve their time, cost and quality goals. This underlines that Megaprojects are usually money pits where funds are simply 'swallowed up' without delivering sufficient returns as a result of not taking mitigating measures to control and manage the inherent risks [69]. In this regard, project managers need to manage and mitigate projects risks appropriately to increase the chance of project success.

Despite the above explanations on the reasons behind the poor delivery performance of Megaprojects, it is painfully apparent that the delivery performance is still getting worse rather than getting better. This is confirmed by Locatelli [21], who argues that the problem of cost overruns in Megaprojects is systematic, with no relevant improvement over time. Therefore, more attention is required to address the poor delivery performance of Megaprojects, which accordingly, motivates the current research study to prompt and offer fresh thinking about risk management in Megaprojects [31].

2.4 The Nature of Megaproject Risks

The literature on risk management has highlighted several and various definitions of risk [70-76]. The Association for Project Management [77] defined a risk event as "an uncertain event or set of circumstances that, should it occur, will have an effect on the achievement of one or more of the project's objectives". The Project Management Institute [78] further clarified the definition of risk as "an uncertain event or condition that, if it occurs, has a positive or negative effect on a project's objectives". HM Treasury [79] defined risk as "uncertainty of outcome, whether positive opportunity or negative threat, of actions and events". Despite the fact that managing opportunities are equally critical to managing and mitigating risks, the focus of the current research study is on the downside of risk (negative threat), namely the unfavourable impacts such events can have on project outputs and/or outcomes when they occur. The rationale behind this is the overriding intention of most risk management approaches is to minimise potential losses.

A considerable amount of studies have been carried out by academics and practitioners to investigate, identify, and understand the nature of MRs [2, 23, 28, 29, 39, 41, 63, 68, 69, 80-87]. It has been argued by some authors that in addition to conventional risks, there is another type of risks that could happen to Megaprojects as a result of the impact of the global aspects on Megaproject [88]. This is supported by Boateng *et al.* [69] who argues that Megaprojects involve unique risks that tend to stretch available resources to the limit and sometimes beyond during the development process. A good explanation is provided by Rolstadås *et al.* [39], who argues that as a project becomes bigger and more complex, other categories of risks start to dominate and become critical to the project's success. The studies presented thus far provide evidence that this Megaproject faces emergent risks that are not usually present in conventional construction projects [39, 41, 69, 88]. Therefore, it is crucial to draw a clear and precise line to distinguish MRs from those that happen to conventional construction projects. In this regard, the current study lists the key differences between MRs and conventional risks, as shown in Table 2.2.

Table 2-2 Comparison between Megaproject Risks and Conventional Risks

Aspect	Conventional Risk	Megaproject Risk
Risk Identification	Rely on historical data	Rely on people with a high level of experience and expertise [89].
Risk Impact	Risk can impact project outputs (cost – time – quality)	Risk can impact both project outputs and outcomes [45].
Risk Analysis	High-quality data is available to suit conventional approaches	Lack of complete and accurate data which limit conventional approaches [6].
Risk Mitigation	With the control of the project team by using typical mitigation measures.	Outside the control of project team requiring new/unique mitigation measurements [56].

Concerning risk identification, Megaprojects by nature are large-scale and complex systems; hence their risks are often difficult to be predicted and identified and even harder to be quantified before they occurrence comparing to conventional risks [90, 91]. The challenge of identifying MRs could be attributed to many factors. For example, the long life cycle of Megaprojects can generate a variety of threats and risks. Further, Megaprojects demand new technologies that can bring new risks that have never been captured before [92]. Moreover, because it is difficult to identify all the stakeholders and/or their agendas in the Megaproject context [64], which is one of the main sources of risks in Megaprojects. Therefore, capturing the stakeholders' risks using classical or standard risk registers or lists seems to be inadequate. Instead, identifying, capturing and understanding MRs requires a multidisciplinary team with a high level of experience and expertise. Furthermore, the identification and quantification of MRs require a balance of project knowledge, Megaproject knowledge, risk analysis expertise, cost estimation expertise and objectivity [90]. However, some authors argued that some MRs such as those associated with natural disasters could be identified and quantified using modern technology, although these risks remain difficult to incorporate into the Megaproject decision-making process [69].

There are a number of important differences between MRs and conventional risks with respect to the extent of risk impact. The extent of risk impact refers to the range of consequences that a risk will cause to the project and its outputs and outcomes. Greiman [41] in her book on Megaprojects noted that, as projects are becoming bigger and more complex in scale, the extent of the risk impact is also going to increase. Greiman further pointed out that these risks can also cause the conversion of a non-critical path to a critical path and can also impact project milestones if the exposure occurs on the critical path [41]. A recent paper by Callegari *et al.* [7] has shown that the economies of scale embedded in Megaprojects face exposure to risk that is disproportionate to the financial economies they can generate, which eventually leads to additional and unjustified costs and delays to the projects. The extent of risk impact is also influenced by scale, complexity and life cycle of the project. For example, in a relatively short life cycle projects, there is a small chance of an independent incident to happen compared to a longer life cycle project, which becomes much more higher [91]. The other issue is that Megaprojects are made up of relatively small projects, and each of these individual projects is associated with high interdependencies. Therefore, any major risk may affect other projects or other activities, even if the risk is outside of the zone of these affected projects.

With respect to analysing the risk impact and probability, the majority of conventional methods of risk analysis rely on determining the expected risk magnitude (probability x impact) based on point estimates [72, 93-97]. These conventional methods tend to focus on quantitative risk analysis based on estimating probabilities and probability distributions of risks regarding time and cost. The effectiveness of these conventional risk analysis methods hangs on the availability, accuracy, quality, preciseness and completeness of data. Considering the scale and complexity and the long-term delivery environment of Megaprojects, these can yield incomplete and inaccurate and incomplete project information, unpredictable and unforeseen events, and uncertain project circumstances. This underlines that the features of Megaprojects can severely limit the applicability and effectiveness of conventional methods in analysing MR. This argument is acknowledged in the literature and by many authors. For example, authors argue that the ranking process of MRs is often not performed sufficiently and exactly, for the reason that the available data and information are vague, inexact, imprecise and uncertain due to the nature of these projects [98]. Therefore, these conventional methods cannot provide the project team with reliable answers and could mislead the decision-making process because it is based on uncertain and ill-defined data. Consequently, these methods could lead to undesirable consequences such as serious cost/time overrun. Recent studies have revealed that the basis of conventional risk management methods for Megaprojects requires a revisit because major risks tend to happen more frequently than what is captured in the early appraising phases [91].

Regarding the mitigation of risk impact, it can be argued that, as the size of projects is getting bigger, it becomes more challenging to mitigate or manage risks as intended in the early phases due to the lack of lessons and information on best practices from similar projects in the past. Authors argued that MRs are typically outside the responsibility of the project team (which has neither the capability, not the authority to manage them) [39]. Furthermore, the expected required resources for mitigating MRs in an appropriate time period and with standard equipment are significantly higher compared with conventional risks where there are plenty of alternatives. For instance, the state government in Australia shut down the airport bus service to force people to use the rail link project to meet the estimated demand. The cost of this action and the contractual compensation to which State Rail Authority was exposed, was estimated to be an extra £200 million at the time, which generated a considerable amount of negative publicity for the project [99]. Now, if we assume that the same risk could happen for a £300 million construction project, the consequences for the project's promoters would be much less. This underlines that, although risk with a particular description can exist in any construction project, the value and influence of that risk would not be the same for Megaprojects.

2.5 Identification of Megaproject Risks

The previous sections provided a general overview of the nature of MRs and illustrated how these are different from conventional risks. Therefore, identifying these MRs is important in order to prepare and design appropriate risk management strategies to manage and mitigate them [23]. Giving the fact that around two-thirds of Megaprojects often associated with high risks, which lead to excessive delay and cost overruns, identifying these MRs become essential. In recent years, there has been an increasing amount of literature on identifying MRs. For example, Boateng *et al.* [69] provide an analytical network process model for risks prioritisation in Megaprojects. Whereas, Lam [23] provides a sectoral review of risks associated with major infrastructure projects. Despite the contribution of these studies, however, few studies have been able to draw on any systematic research into identifying a comprehensive list of MRs.

In order to conceptualise and synthesise the existing body of knowledge of MRs, a systematic literature review supported with content analysis method is adopted as discussed and justified in Section 5.4 in Chapter 5. The current research study follows the approach of content analysis proposed by Elo and Kyngäs [100], which consists of three steps. Step 1 (preparation), which aims to identify, select and prepare the unit of analysis [100]. Step 2 (organising), which involves three sub-steps: open coding, creating categories and abstraction [100]. Step 3 (reporting), which involves reporting the analysis process results with sufficient detail so that readers have a clear understanding of how the analysis was carried out and its strengths and limitations [100].

In this research study, the preparation step involved five sub-steps, which are discussed with more details in Section 5.4.1. These five sub-steps include database selection, keyword selection, source of information selection, journal selection, and search scope selection were conducted to refine and screen the literature as shown in Figure 5.4. The preparation step results in selection of 68 documents to be analysed in the next step of the content analysis process. However, only 57 of the 65 documents were downloaded due to restrictions from their publishers.

The organising step involved three sub-steps: open coding, creating categories and abstraction, which are discussed and justified with details in Section 5.4.2. In the organising step, each one of the 57 documents was carefully reviewed in order to screen those relevant to the research question. After this screening process stage, a total of 17 documents were identified as relevant for subsequent analysis as listed in Appendix B. At this stage of the analysis, each one of the 17 documents was read through to identify any risk that could potentially affect Megaproject delivery performance. Once a risk was identified from the document text, a code (name) was developed to link that risk in the document, as shown in Figure 5.5. At the end of this stage, hundreds of codes were derived from the 17 documents and were grouped into a number of categories.

The categorising stage aims to classify data/codes that share similar features or properties into broader higher-order categories in order to reduce the number of categories [101], as shown in Figure 5.5. In the current research, the identified risks (codes) in the open coding stage that contributed to the same meaning were grouped under a single category with a unique ID such as MR1, as shown in Figure 5.5. The categorising process was repeated until distinct sets of categories were obtained, where each category represents a distinctive MR, as shown in Figure 5.5. At the end of this stage, 38 unique categories were formulated as MRs, which are then defined and described in Appendix C. In this research, the abstraction process was continued until all codes and categories had been extracted from text documents and organised, as shown in Figure 5.5.

After conducting the comprehensive literature review and content analysis, and after removing the duplicates and merging similar risks, a total of 38 potential MRs were identified and reported in Step 3, as listed in Table 2.3. The sources used in the content analysis (selected documents or references) to reach this comprehensive list of 38 MRs are listed in Appendix B. The identified 38 MRs are briefly described and classified in Appendix C and Appendix D respectively. The identified 38 MRs will be utilised as the main source to extract and identify MCRs.

The comprehensive list of MRs could be used as an important tool for helping Megaprojects practitioners and decision-makers with a better understanding of MRs; hence, exclude conventional risks deemed irrelevant to Megaprojects or those with not directly impact. It also can be used as a tool for ranking and prioritising MRs on a different basis, such as based on their probability of occurrence and impact on project outputs [102]. Therefore, the list of MRs could help practitioners/academic to assign appropriate mitigation measures to those MRs deemed to be common and critical to all Megaprojects.

Table 2-3 Megaproject Risks

ID	Name	References
1	Adaptability to design changes	[24, 46, 61, 69, 103-109]
2	Adaptability to policy changes	[24, 61, 67, 69, 80, 107, 110-112]
3	Environmental impact	[24, 46, 67-69, 80, 104, 107, 111]
4	Financial difficulties	[46, 61, 67, 68, 80, 106, 107, 111, 112]
5	Incompetent contractor	[46, 61, 103, 106-111]
6	Political or public opposition	[24, 46, 61, 67-69, 80, 110, 111]
7	Adaptability to influential economic events	[24, 46, 61, 67-69, 80, 104]
8	Adaptability to legislative changes	[24, 61, 67, 69, 80, 104, 110, 111]
9	Adaptability to unforeseen site conditions	[46, 69, 80, 104, 106, 107, 111]
10	Incomplete contract	[61, 103, 105-108, 110]
11	Adaptability to unproven engineering techniques	[24, 67, 69, 80, 107, 111]
12	Contractual disputes	[24, 46, 69, 103, 106, 108]
13	Lack of operability	[46, 104-106, 108, 109]
14	Force majeure	[46, 61, 69, 80, 104, 107]
15	Lack of resources	[67, 69, 80, 105, 107, 108]
16	Aligning stakeholders' expectations	[67, 69, 103, 108, 112]
17	Lack of management oversight	[24, 80, 107, 108, 112]

ID	Name	References
18	Adaptability to inflation rate volatility	[46, 69, 107, 109]
19	Adaptability to market volatility	[24, 67, 108, 112]
20	Delay in project approvals and permits	[69, 105, 107, 108]
21	Inappropriate risk allocation	[103, 105, 106, 112]
22	Lack of integration between key parties	[24, 46, 105, 111]
23	Uncompetitive tender	[46, 106, 110, 112]
24	Delayed payments	[46, 106, 107]
25	Poor public decision-making process	[69, 80, 112]
26	Adaptability to foreign exchange fluctuation	[46, 69]
27	Breach of contractual provisions	[110, 112]
28	Government intervention	[67, 80]
29	Land acquisition and compensation problem	[68, 69]
30	Adaptability to changes in tax regulation	[69]
31	Adaptability to decrease in revenues	[80]
32	Adaptability to interest rate volatility	[69]
33	Adaptability to political instability	[69]
34	Contract/Concession termination	[69]
35	Adaptability to scaling-up	[68]
36	Lack of supporting utilities and infrastructure	[105]
37	Unrealistic demand expectations	[111]
38	Unsuitable domestic legal framework	[112]

2.6 Summary

This chapter was aimed to understand the unique nature of Megaprojects and differentiate it from conventional construction projects. This chapter has shown that delivery performance of Megaprojects is globally disappointing in terms of cost and time. It also has shown that Megaprojects are not merely a scaled-up version of conventional construction projects. Instead, Megaprojects significantly differ from conventional construction projects concerning many aspects such as scale, complexity, stakeholders, finance, implementation, operation and sensitivity to the global aspects. This difference is mainly attributed to the unique characteristics of Megaprojects, which collectively make Megaprojects associated with risks not exist in other conventional projects. The chapter introduced a comprehensive list of MRs by using a systematic literature review with content analysis method.

Chapter 3 Critical Appraisal of Risk Management in Megaprojects

3.1 Introduction

This chapter aims to build the theoretical foundation upon which the current research study is based. For that purpose, the chapter reviews the theories and relevant literature and discusses current practices on risk management in Megaprojects. This chapter consists of seven sections, including this introduction. Section 3.2 discusses a generic process of risk management by presenting and discussing the standard components and steps and ranges of tools and strategies used for managing risk. Section 3.3 discusses the importance of managing risk in Megaprojects, concentrating on the role of risk management in the appraisal phase. Section 3.4 provides a critical appraisal of contemporary risk management approaches in the UK against Megaproject challenges. Section 3.5 reviews and critiques previous academic studies performed on the topic of risk management in Megaprojects to reflect where the current research study stands in a wider context; hence identifying the gap in knowledge. Section 3.6 critically discusses the matters arising from the review that are considered worth researching as well as identifying and delineating the research problem. Lastly, Section 3.7 summarises the chapter.

3.2 Risk Management Process

The risk management process is well recognised by both academics and practitioners as one of the most important management functions that help in project planning and control. It is defined by the British Standard BS-62198 as "the systematic application of management policies, procedures and practices to the tasks of establishing the context, identifying, analysing, evaluating, assessing, treating, monitoring and communicating risks in a way that will enable organisations to minimise loss and maximise opportunity in a cost-effective way" [113]. It is also defined by HM Treasury as a process that has a series of well-defined steps to support better decision-making through a good understanding of the risks inherent in a proposal and their likely impact in order to ensure an organisation makes cost-effective use of a risk process [114]. The above definitions underline that a typical risk management process can be simplified into four steps: risk identification, risk analysis, risk response and risk monitoring [72, 93, 96]. Each one of these steps is discussed in the following subsections.

3.2.1 Risk Identification

Initially, risk identification is the start point and the key element in the process of risk management. It can be defined as the process of systematically and continuously identifying, categorising, and assessing the initial significance of risks associated with a construction project [72]. Despite the fact that the effectiveness of this process can be obtained in early project phases, it has been regarded as an iterative process that needs to be performed during all project phases. Thus, the definition above underlines the importance of treating risk identification as a dynamic process that needs to be conducted continuously over the project life cycle, rather than as a static process. Risk identification can bring many advantages to the project management team. However, the main purpose of this process is to provide a comprehensive list of the potential risks that may threaten the project's success. Therefore, it brings considerable benefits to the project by providing early indications of the need for risk management strategies [115]. Moreover, it helps project managers and decision-makers to act proactively after identifying future scenarios of uncertainty [116].

The risk identification process involves the project key participants, key stakeholders and other managers affected by or who affect the project, and individual experts who can be hired to identify potential risks based on their experience [117]. Some authors argued that the identification of risks is not a fundamentally difficult issue, but it depends mainly on the experience and the expertise of the evaluator [118]. Therefore, special attention must be directed to the selection of those who perform this process, because their judgements may be subjective, and they could fail to identify unforeseen risks that may appear later during the implementation and operation phases. The participants in the process of risk identification tend to use several tools and techniques to produce a risk register. There are three main techniques to identify risks: checklists, brainstorming and historical data from previous projects [115].

3.2.2 Risk Analysis

Risk analysis has been argued by many authors to be a critical step in any risk management approach as it links the identified risks and the actions against these risks [72, 119]. It aims to quantify the effect on the project of the identified risks [115] to determine which risks take the highest priority and which risks require further analysis [120]. It is defined as "the process in which risks are examined at various degrees of detail to determine the extent of the risks, how risk elements are related to each other, and which ones are the most important to deal with" [121]. This underlines the fact that risks need to be assessed and managed in a comprehensive manner; in other words, each risk factor needs to be assessed based on its effect on other factors.

Risk can be analysed using quantitative and/or qualitative analysis methods [78, 119, 122, 123]. The extent of the use of qualitative and/or quantitative risk analysis methods is determined mainly by the project's nature and other factors such as the associated cost and time. However, integrating both quantitative and qualitative analysis methods can provide a comprehensive analysis by overcoming the limitations of each method.

According to Perry and Hayes [71], the common principle behind using any method of risk analysis is to allow a range of values for the input data. However, in practice, obtaining adequate information as input data, and analysing it, is difficult [120]. Such difficulties can be associated with complex, long-term duration and expensive projects as the sources of information on risk likelihood, and the consequence may be insufficient to provide complete, precise and detailed data. The main sources of information include but are not limited to: records and other sources of historical data; relevant experience; reviews of research into project success and failure; experiments with prototypes; market testing and research; application of behavioural, financial, economic, engineering and/or other relevant models; and use of specialist and/or external expertise [120].

3.2.3 Risk Response

According to the logical workflow of the generic risk management process, the next process is to respond to the outputs of the risk analysis process, since there is still no plan of the measures to counter and mitigate the likelihoods and impacts of these risks. Therefore, the risk-responding process has two aims: Firstly, it provides a plan to manage risks. Secondly, it identifies risk owners [124]. The following sections present the four strategies of risk response: risk avoidance, risk-mitigating, risk transfer and risk retaining [102].

3.2.3.1 Risk Avoidance

Risk avoidance has been referred to by other studies as risk elimination [125]. According to the conclusion of Perera *et al.* [126], avoiding risk is an effective strategy which can be realised at the early stage of proceedings. For instance, the project developers may call for reconsidering the project idea or seek other viable projects if the risk impact is so high that it can severely threaten the project's viability [115].

3.2.3.2 Risk Mitigating

Mitigating risk is defined as the process taken by a project participant to articulate and introduce measures to manage and/or reduce the adverse impact and/or probability of a risk to an acceptable level [71, 127-129]. Some authors argued that, instead of avoiding risk, risks could be reduced; this could be achieved through changing a project's characteristics, such as using different construction technology or using a different design, etc. that have a slight effect on the schedule and budget [102]. There are two ways to reduce risks: decreasing the occurrence likelihood of a risk and decreasing the financial outcomes in the event of a risk occurring [72].

3.2.3.3 Risk Transfer

It has been argued by some authors that risks without reasonable prices need to be distributed to different participants in order to achieve the best project management aspects [48]. Baker *et al.* [125] argued that transferring a risk may be treated as a form of risk reduction. Commonly, four situations have been recognised for transferring risks in the construction industry: client to contractor and designer; contractor to the subcontractor; client, contractor, subcontractor or designer to the insurer; and contractor or subcontractor to surety [71]. However, risk needs to be transferred to the party best able to manage it because the inappropriate distribution of risks can lead to project failure [99].

3.2.3.4 Risk Retaining

A risk-retention technique is particularly suited to the risks located within the firm's internal management control [125]. Retaining risk can be either planned or unplanned [72]. Consequently, these risks would be controllable or uncontrollable, respectively [71]. However, according to Perera *et al.* [126], it has been concluded that, despite the variation in risk-responding techniques, there is no ideal method to handle risk; nevertheless, the selecting of risk response depends on the nature of the risk and the project circumstances.

3.2.4 Risk Monitoring

Monitoring risk or following-up action is the last stage in the process of risk management; however, the process of risk management might not end at this stage [130]. Although risks have been identified, analysed and managed, new risks and opportunities appear over the life cycle of the project, which requires alterations in project implementation plans [63]. Therefore, the strategies adopted to manage project risks must regularly be monitored and maintained in order to compensate for changes in risk at different levels [72]. According to HM Treasury [79], the management of risk has to be monitored and recorded for three reasons: first, to monitor whether or not the risk profile is changing, second to gain assurance that risk management is effective, and third, to identify when further action is necessary. In this process, risks that have occurred or that have been dealt with may be removed from the project risk register; therefore, the process of risk monitoring does not finish until project completion is achieved, which may be a lengthy process when using a risk management approach [130]. A number of tools and techniques have been identified by HM Treasury [79] to support achieving the following-up process: risk self-assessment; stewardship reporting; and risk management assessment framework.

3.3 Role of Risk Management in Megaprojects

The pace of change in the construction industry has imposed additional demands on construction project management. Risk management is recognised as a fundamental part of project management by global professional institutes like the Institute of Project Management (IPM) [131] and the Association for Project

Management (APM) [132]. It is widely accepted as the best approach that could provide practitioners with a comprehensive and systematic process to identify, assess, control, manage, mitigate and monitor risks associated with projects [72, 96, 133, 134]. Therefore, it is an essential process to predict, examine and take proactive actions in order to reduce risks or elements that could affect the delivery performance of projects [67], and hence to achieve the long-term project outcomes.

Although a structured process for risk management is needed across the entire life cycle of a project, the major inputs and effectiveness take place during the appraisal phase [102, 135]. This is because decisions undertaken within the project appraisal phase tend to have a major impact on the final cost of the project [71]. This argument is reinforced by Smith [136] who argued that it is possible to make changes that are relatively cost-effective at the early project appraisal phase, as illustrated in Figure 3.1. According to Smith [136], around 10% of a project's capital is invested during the appraisal, while the decisions made at the sanction stage will freeze around 80% of the remaining cost. Therefore, it can be argued that the ability of the project team to reduce project costs will be decreased over time while the costs of change will be higher due to the contractual commitments.

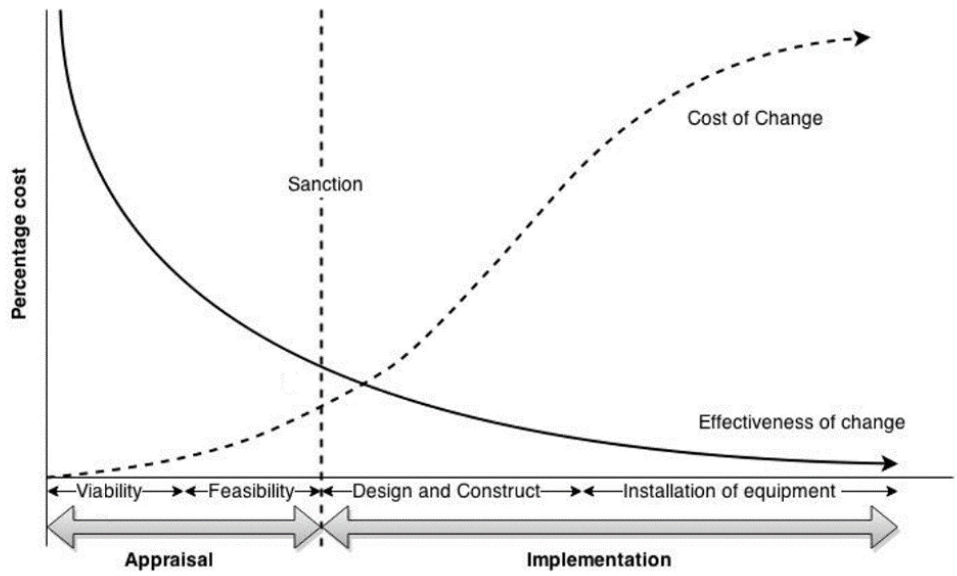

Figure 3-1 Percentage Cost Plotted Against Time [96]

Although risk management is at the core of every project regardless of size, industry, or complexity, it has always been a matter of debate in Megaprojects for several reasons [45, 53]. Due to scale, complexities, long life cycle, number of stakeholders, and exposure to interrelated and pervasive drivers of risk, Megaprojects by their nature face emergent risks that are not usually present in conventional construction projects [39, 41, 69, 88]. Due to the evolving nature of Megaprojects, risks encountered during the appraisal phase are usually very different from those encountered during the implementation or operation phases [64]. Therefore, it can be argued that understanding, identifying, managing and mitigating risks in Megaprojects are challenging tasks [51]. Accordingly, if MRs are not managed and/or mitigated properly, it can lead to contractual disputes among the stakeholders, huge interfaces, excessive delay and cost overrun [35, 51]. Further, it can escalate to affect the whole project and sometimes create strategic risks to their sponsors and/or delivery organisations [82]. Therefore, it can be argued that risk management is a critical factor for planning and managing Megaprojects.

The other reason behind the importance of risk management in Megaprojects is due to the scale of these projects, where the size of failure costs is particularly high [137, 138]. The cost of Megaprojects, which is defined in billions of pounds or dollars, need substantial funding support by governments [137], which represents a significant challenge. Hence, a small percentage of cost overrun on a multi-billion-pound Megaproject can result in it going millions of pounds over-budget, leaving clients dissatisfied and taxpayers often out of pocket. Owing to the scale of the impacts that Megaprojects can have on the public, environment and economy [86, 139], sometimes the devastating consequences of not managing risks properly can be sudden bankruptcy of companies or government upheaval [24]. Therefore, it can be argued that risk management plays a crucial role in the success of Megaprojects. This crucial role is not just about improving the delivery performance of Megaprojects but is principally vital to the survival of organisations and institutions like governments. Thus, risk management should be an intrinsic part of Megaproject investment decisions [140].

3.4 Critical Appraisal of Existing Risk Management Approaches in Megaprojects

This section seeks to review and evaluate the effectiveness of contemporary risk management approaches in a Megaprojects context to identify the weaknesses and limitations if any. The procedure used for evaluating risk management approaches is based on gradually structuring the literature on Megaprojects and comparing its characteristics with some widely used risk management approaches in the UK, to research the extent of coverage of each approach against the project management challenges of Megaprojects. This procedure is also applied by Sarantis *et al.* [141] who used it to provide a critical appraisal of the contemporary project management approaches against the challenges associated with e-government initiatives. This critical appraisal procedure consists of the following three steps, as shown in Figure 3.2.

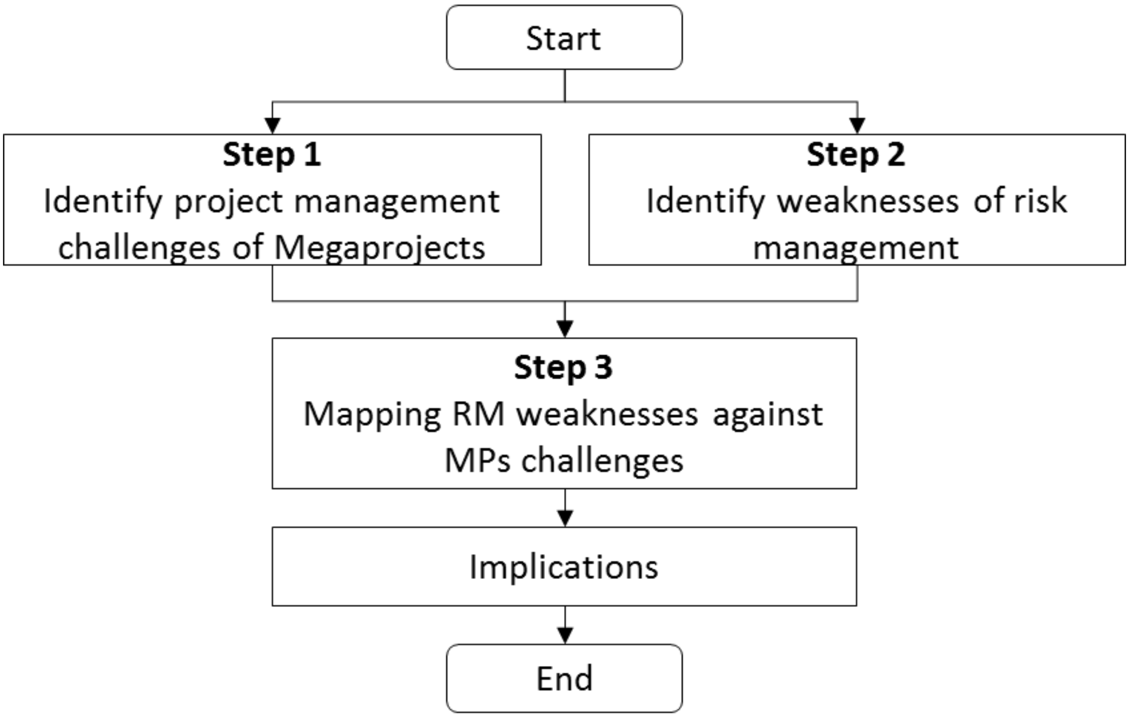

Figure 3-2 Critical Appraisal Process for Existing Risk Management Approaches

Step 1 – Identification of Project Management Challenges of Megaprojects. This step involves a detailed review of the current literature in the Megaprojects area to identify factors found to challenge the success of project management in Megaprojects. This review includes the scanning of top journals, book chapters and case studies in Megaprojects with a focus on risk management practices. The analysis in this step is focalised to derive the specific risk management challenges that are being confronted in the Megaprojects domain.

Step 2 – Identification of Weaknesses of Existing Risk Management. This step aims to identify the limitations of existing risk management approaches by examining four of the most popular risk management approaches that are currently applied in the UK context.

Step 3 – Mapping the Limitations of Risk Management against Megaproject Challenges. This step involves outlining the limitations of risk management against Megaproject challenges in order to find out if there are any gaps that need to be filled.

3.4.1 Step 1 – Identify Project Management Challenges of Megaprojects

3.4.1.1 Lack of Statistical Data

Unlike conventional projects, where there are adequate statistical databases on risk, procedures, routines, practices or lessons from similar past projects, there is a lack of statistical data on Megaprojects because such projects are limited in number and unique [37]. A probable explanation of this is each Megaproject has its own set of distinctive features, critical success factors and conditions of implementation [142, 143]. Further, Megaprojects are planned and implemented within a unique set of social, technical, economic, environmental and political (STEEP) factors [144, 145]. In fact, due to their innovation and scale nature, Megaprojects demand sophisticated engineering and unproven solutions to solve problems [146], which could be attributed to project contextual factors. This is also supported by Flyvbjerg [147], who argues that there is a “uniqueness bias” among planners and managers, who tend to see their Megaprojects as singular because technology and designs are often non-standard, which in turn impedes learning from other projects. Other authors have also supported the previous argument by arguing that the uniqueness of Megaprojects renders benchmarking from databases generated out of previous projects that have already been completed [148]. This means the unprecedented historical data that need to be obtained to assess future Megaprojects will be different to some extent or inappropriate. Therefore, it is challenging to make a list of general success and failure factors which can apply to all Megaprojects [149]. Therefore, it can be argued that both the lack of frequency and the unique nature of Megaprojects increase the challenge of developing effective learning processes from previous projects; hence adequate statistical databases.

3.4.1.2 Lack of Complete Data

In addition to the lack of statistical data, the second challenge in managing risk in Megaprojects is the lack of complete data [16, 150]. There are four likely causes for the lack of complete data in Megaprojects: the lengthy and turbulent development process, number and diversity of stakeholders, implications of unproven technologies, and evolving of best practices.

Unlike conventional projects, the development of Megaprojects has been characterised as “a long gestation process” [151]. While the start and end points can be known in conventional projects, the endpoint of a Megaproject is unknown. Some authors consider that the life cycle of a Megaproject is more than 50 years [29]. This lengthy time-horizon can create more challenges in identifying the long-term needs of the project [152]. For the same reason, lots of events that are often unexpected might occur with a negative or positive impact on the project objectives [153]. For instance, the long life cycle of Big City Road Circuit Brno project (more than 50 years) was associated with significant changes in the technology of construction methods, which eventually led to considerable cost overruns and project delivery delays [118]. Megaprojects are, therefore operating in a long-term environment that can yield incomplete and inaccurate information about different project aspects.

In comparison with conventional projects that require typical construction methods and/or technologies, Megaprojects demand new technologies and sophisticated engineering and involve unique solutions to challenging problems [92, 146, 153, 154]. However, many of the technological innovation elements associated with unforeseen risks can bring new risks that have never been captured before [92, 142]. For instance, it is challenging for the project team to assess the applicability of a new construction technology 10 years ahead as there are no adequate records or comparable data. Therefore, without proper assessment and mitigation, these technology-related risks could impact the project objectives such as via cost overrun, schedule slippage and increases in operational problems [155]. For instance, the construction team on the Korea Train Express (KTX) project used a unique rail welding system of having no expansion joint in their project, which affected the project schedule and caused delays [65]. Such unexpected risk tends to result in additional costs, which are inadequately accounted for in initial cost estimates in most cases [28]. Therefore, it can be argued that applying new technological innovations in Megaprojects can yield incomplete understanding (data) about their potential implications on the project objectives.

Compared to conventional construction projects where may involve several levels of relationships with few actors in each level [156], Megaprojects require a large number of stakeholders with different targets, geographical locations and working cultures who collaborate over the project life cycle [61, 157]. Further, stakeholders in Megaprojects can come and go and with the new beliefs and approaches [158]. The involvement of numerous participants could lead to complex stakeholder interrelationships and conflicting interests in the project [159]. Kardes *et al.* [63] argued that the multi-layer relationships between the stakeholders are the key source of risks in Megaprojects because their goals are not properly aligned. These risks arise from the difficulty of anticipating the future behaviour of project players, especially in a long-term context. For instance, these players can collaborate or disagree on a particular aspect of the project; accordingly, this can affect the project positively or negatively. The negative side can be articulated as conflict or moral hazards [81]. Therefore, due to the multiplicity and a large number of stakeholders in Megaprojects, it is difficult to obtain complete and accurate data about the anticipated actions of these players at the early appraisal stage. Hence, any decision made based on incomplete information will be misled and potentially dangerous to project delivery [61].

3.4.1.3 Lack of Experts

As complex, open and dynamic systems, Megaprojects require higher levels of technical skills, competent human resources and managerial capabilities than other conventional construction projects, and they are subject to diverse disturbances [62, 160]. Conversely, most countries experience a shortage of many of these levels of expertise and requirements, which obstructs the development and successful execution of Megaprojects [15, 47, 142, 160-163]. The shortage of high-quality and experienced management personnel has been reported as one of the main causes of the poor performance of Megaprojects [142, 164]. Van Marrewijk *et al.* [142] argued that Megaproject cost overruns should be seen as the result of the normal practice of professionals operating with limited knowledge. The shortage of expertise could possibly be attributed to two key factors: the limited number of Megaprojects and employee turnover due to the long life cycle of Megaprojects. Further, shortage of providing quality education and professional training programmes is a major challenge that leads to an inability to provide Megaprojects with highly qualified human resources with the right skills that match project demands and geography [160].

3.4.1.4 Very Complex

Megaprojects are characterised as very complex undertakings in two aspects: technical and organisational [47, 67, 165]. The term "complexity" is defined as "the degree of manifoldness, interrelatedness, and consequential impact on a decision field" [166]. Technically, Megaprojects involve a large number of interrelated elements that affect the cost and overall ability to deal with risk, such as materials, activities, equipment, methods, systems and participants [24]. These elements can create a large number of interdependences, which increase the challenges of delivering the project smoothly. According to Baccarini [167], the inherent complexity hinders the clear identification of Megaproject goals and objectives. For instance, it is difficult for a project's appraisers to accurately know the potential influence of a particular complex system on the project's objectives since most of these systems, by definition, are unique. This could increase the difficulty in articulating the complete picture of the project, and hence, unforeseen events will not be captured. Therefore, their complexity has been argued by some authors as a chronic disease of Megaprojects [81], which can affect their success [53]. Owing to the inherent complexity, some authors have argued that managing Megaprojects by traditional approaches is difficult [168]. Due to their complexity and large scale, the costs of these projects are difficult to evaluate accurately, hence incomplete and inaccurate information about the actual initial cost and expected income can arise.

3.4.2 Step 2 – Identify Weaknesses of Contemporary Approaches to Risk Management

A wide range of guidebooks, standards, codes of practice and frameworks have been developed by professional institutions and academics to support practitioners to manage risks in construction projects. For example, the Orange Book, which is a guidance document that has been established by HM Treasury, provides a basic introduction to the concepts, development and implementation of risk management processes in government organisations [79]. These basic principles have been supplemented with more detailed guidance called the Green Book [169] as central government guidance on appraisal and evaluation. The Institution of Civil Engineers (ICE) has recently updated a guidance framework for analysing and managing the risks involved in projects called Risk Analysis and Management for Projects (RAMP) [170]. Similarly, the Association for Project Management (APM) has guidance called Project Risk Analysis and Management (PRAM), which can be modified and adopted for various project situations [132]. The International Organisation for Standardisation (ISO) provides ISO Guide 73:2009, which is a coherent approach to the description of activities relating to the management of risk and the definitions of generic terms related to risk management [171]. Based on this standard, the British Standards Institution (BSI) modified BS 31100:2011, which is a COP and guidance relating to risk management for the implementation of BS ISO 31000 to be adopted for various project situations [172].

Despite the achievement of the above approaches in construction projects, they have six common limitations. The first issue is that most of the existing risk management approaches are mainly based on quantitative techniques that require numerical data. However, very often, it is difficult to represent MRs numerically. The second issue is conventional risk management approaches overly rely on the accuracy and completeness of data to provide realistic results. They tend to use databases from previous projects in order to assess potential risks [148]. However, as Megaprojects have a high level of complexity and a very long life cycle, it is difficult to establish comprehensive, accurate and complete databases; hence, unrealistic and meaningless outcomes will be produced.

The third issue is that the minimum resource requirement to apply classic risk management is obviously just one individual within an organisation with experience of using conventional approaches [173]. However, if expertise does not exist within the organisation, it can be readily acquired from outside consultants [173]. To what degree quantitative analysis is appropriate depends on the nature and quality of the data available for particular risks, the nature of the project, potential consequences, and whether analyses can provide additional useful information [120]. The fourth issue is associated with the complexity of risk analysis. The Megaproject context is likely to change, and new risks can occur, although they were not identifiable when first identification took place. As a consequence, exhaustiveness is never achieved by any method, even though the identification can be facilitated by previous lessons learned [174].

The fifth issue is associated with the inconsistency of risk definition. It has been argued by some academics that, although there are numerous risk checklists and risk breakdown structures proposed by different academics, the major drawback in some of these lists is “inconsistency” in terminology [175]. The word risk may be used to imply sub-risks (sources), consequence or probability of occurrence of a negative event [175]. Finally, the last issue is associated with the interpretation of outputs. The nature of the risk management service can rely on the managers’ quantitative background and their ability to interpret and apply risk management concepts [176]. Difficulty in understanding and interpreting the outcomes of the risk management process is recognised as one of the barriers of the application of classical risk management [177].

3.4.3 Step 3 – Mapping of RM Weaknesses against MP Challenges

This section aims to map risk management weaknesses against the project management challenges of Megaprojects in five risk management methodologies: Green Book, RAMP, PRAM, BSI and ISO, as listed in Table 3.1. These models are the dominant approaches that are currently applied to manage risks for Megaprojects in the UK context and globally. It can be seen from Table 3.1 that the project management challenges of Megaprojects are nearly all considered in one or more of the five risk management approaches. For example, the Green Book relies on databases from previous projects to assess risks and adjust the optimism bias in the appraisal of Megaprojects [148]. However, in

Megaprojects, it is quite difficult to establish comprehensive, databases; hence, unrealistic and meaningless results could be produced. Therefore, it can be argued that many of the conditions for the successful application of these approaches are not satisfied in Megaprojects. The project management constraints of Megaprojects severely limit the capability of conventional methods to manage such projects, to the extent that these methods could not produce meaningful and realistic results.

Table 3-1 Mapping of Risk Management Weaknesses and Megaproject Challenges

Megaproject Challenges	Weaknesses	Contemporary Risk Management Approaches				
		Green Book	RAMP	PRAM	BSI	ISO
Lack of Statistical Data	The lengthy period generates incomplete data, which limits the capabilities of conventional methods that rely on high-quality data. The interrogation of in-house historical databases is probably the best source of data to assess risk occurrences or consequences of risk events, but in many cases, these databases are inadequate or disjointed, unavailable, or supplemented with personal information bias [72].	Applied	Applied	Applied	N/A	N/A
Lack of Complete Data	The huge number of studies in the international literature has generally focused on the analysis of past events, i.e. on what had gone in the right or in the wrong direction, trying to summarise the lessons learned for the future [87]. These kinds of studies are essential, but, obviously, they do not take into consideration those projects that never got started due to the negative output from the risk analysis, and so it is very difficult to measure lost opportunities [87].	Applied	Applied	Applied	N/A	N/A
Lack of Experts	Among the challenges in the public sector, project management is the shortage of good project managers in the public sector [47]. Therefore, the number of experts with broad experience in managing and mitigating risks in Megaprojects is small. By definition, a Megaproject will take many years from inception to completion, and those who complete it will not be those who were there at the inception. Inevitably, those who are at the end of a project which is delayed or late in delivery will cast blame on poorly constructed planning earlier on, etc. This underlines that the view of the major risks will be skewed, by both the discipline of the person making the judgement and by the stage of the Megaprojects in which they have been involved.	N/A	Applied	Applied	Applied	Applied
Very Complex	Complex projects like Megaprojects are now recognised as being applications where traditional approaches, tools and techniques have significant shortcomings and maybe at best unsuitable or at worst counterproductive [6].	Applied	Applied	N/A	Applied	Applied

3.5 Related Studies of Risk Management in Megaprojects

Studies over the past two decades have provided important information on risk management in Megaprojects. This section aims to review and critique previous academic studies performed on the topic of risk management in Megaprojects to reflect where the current research study stands in a wider context; hence identify the gap in knowledge as follows.

Miller and Lessard [51] investigated and collected data from 60 large engineering projects across the world to identify, classify and rank risks that occur at the early front-end period of each project. These authors propose several managerial strategies to cope with risks in this sort of project according to the extent of risk control. However, the main limitation of this study is the difficulty of how to differentiate between controlled risks and uncontrolled risks.

Flyvbjerg *et al.* [28] provided a comprehensive analysis of cost overruns on a sample of 258 public sector transport Megaprojects. This study revealed that 90% of Megaprojects suffered cost overruns, and it concludes that the key principal cause is optimism bias. Accordingly, Flyvbjerg *et al.* [178] provide a procedure for dealing with optimism bias in transport Megaprojects in the UK. However, the limitation of Flyvbjerg's study is, obviously, that it does not take into account Megaprojects that will not suffer cost overrun.

Aritua *et al.* [140] presented empirical evidence from the UK public sector identifying risks that are common to or amplified in Programmes environment. However, the multiple case study approach that has been adopted in this study limits the generalisability of the result, especially as it is based on only five cases.

Rolstadås *et al.* [39] developed an executive approach with a new way of thinking about managing risks in major capital projects. The authors rely on a deep understanding of the engineering and construction industry to reflect the best practices in managing major capital projects. The approach consists of three major elements: reshaping the governance system, improving the decision process and a new strategic planning model.

Kardes *et al.* [63] provided an exploratory approach to identify key characteristics of global Megaprojects and factors contributing to disappointing outcomes and offer a risk management framework and managerial prescriptions for enhancing success. One criticism of this study is that its proposed risk management approach relies upon the availability of complete and accurate data to produce meaningful outputs, which is not the case for Megaprojects.

In her book, Greiman [41] provided an analysis of the difficulties in managing a Megaproject during each phase and throughout the life span of the project. Greiman explains the many technical marvels of the Big Dig but, more importantly, about the day-to-day obstacles, challenges, and uncertainties faced by the engineers and many other participants in this Megaproject.

Boateng *et al.* [69] adopted the Analytical Network Process and combined it with a new Risk Priority Index to model risks analytically, based on data collected from the Edinburgh Tram Network project at the construction phase. The main weakness of this study is the questionnaire survey used to identify risks that may distort the output because the number of Megaproject experts is relatively small.

Love *et al.* [31] proposed an approach to consider the interdependencies between causes that lead to cost overruns in Megaprojects based on the incorporation of probabilistic theory. A serious weakness with this study, however, is that probability theory fails to handle the situation that arises due to the presence of vague information in the data in Megaprojects [114, 179].

Despite the contribution of the above studies to risk management research, there is a dearth of studies that have attempted to investigate MRs and differentiate them from risks associated with conventional projects. The other observation is that Megaproject Common Risks (MCRs), which are strongly linked to the poor performance of Megaprojects, have received little attention in the existing literature. The current research seeks to bridge this gap by identifying and/or managing MCRs in a better way. To achieve this goal, three research questions were formulated: Is there a better way to improve risk management in Megaprojects beyond the existing conventional approaches? What are MCRs? Is there a better way to think about MCRs?

3.6 Critical Discussion

Megaprojects involve various risks, and the successful implementation of such projects depends on the effective management of key risks. Risk management is widely accepted as the best approach to managing, controlling and monitoring risks associated with projects**.** A range of guidebooks, codes of practice and protocols have been produced to assist the risk management process in project environments. A critical appraisal of existing approaches to risk management revealed that many of the conditions for the successful application of these approaches were not satisfied in Megaprojects; in particular, problems arose from the lack of complete and statistical data. These constraints severely limit the capability of conventional methods to manage risks in Megaprojects, to the extent that these methods could not produce meaningful and realistic results. This is supported by many authors, who have argued that current risk assessment performs ineffectively and inaccurately in relation to Megaprojects [147, 148, 168, 180-182] because these methods depend on inexact, imprecise and uncertain data [39, 53, 98].

The current research study argues that to keep using conventional risk management approaches in Megaprojects may not improve the current situation for three reasons. First, conventional risk management approaches do not differentiate between Megaprojects and small or conventional projects as they rely upon best practices. However, what is perceived as best practice or good industry practice may be applicable only in certain circumstances [6]. The environment in which Megaprojects operate is evolutional, complex and turbulent; hence, conventional approaches are not well suited to such conditions. Second, conventional risk management approaches tend to mitigate symptoms, not causes. Often, the symptoms are accepted as the problem rather than the underlying root causes of these symptoms being investigated [41]. Third, conventional risk management approaches are very expensive because they consider that all Megaprojects will suffer from poor performance while they do not take into consideration that around 30% of Megaprojects have a satisfactory delivery performance [6].

In light of the above argument, without a better understanding of the scale and complexity of Megaprojects, the underperformance in delivery of such projects will remain problematic. Therefore, more attention needs to be paid by both academics and practitioners to the way of managing and mitigating risks in Megaprojects. This emphasises the need for a new approach to risk management that is able to cope with the scale and complexities of Megaprojects. This is supported by authors like Dimitriou *et al.* [44], who advocated for a dramatic change of mind-set concerning the way in which Megaprojects are positioned, framed, planned and ultimately judged. Similarly, Thamhain [24] suggested that, in order to manage risks effectively in complex systems like Megaprojects, project management methodologies that go beyond conventional approaches are required. A similar argument was recently made by Callegari *et al.* [7], who suggested that Megaproject practitioners need to go beyond traditional risk management in order to deal with the extreme uncertainty surrounding this sort of project.

The above argument provides further strong evidence on which to base the answer to the research question: Is there a better way to improve risk management in Megaprojects beyond the existing conventional approaches? What are MCRs? Is there a better way to think about MCRs? Therefore, the current study aims to fill this gap by advocating a complete and fresh change to the current risk management thinking in Megaprojects and developing a new approach to risk management that is able to manage and mitigate MCRs in a better way. Such an approach can help to overcome the weaknesses in the existing RM approaches. Therefore, the new approach should be designed to focus on creating a context that enables project managers to focus on MCRs that could occur in all Megaprojects and only in Megaprojects. It also needs to be practically applicable, reflecting the realities of engineering and a deep understanding of what could be applied to Megaprojects and what would not be applicable. It also needs to be up to date, reflecting the existing and anticipated conditions as well as the latest industry research.

3.7 Summary

This chapter has reviewed the literature on risk management within the Megaprojects context. It has shown that, despite improvements in project risk management, there has been little noticeable improvement in the outcomes of Megaprojects compared to conventional construction projects. A critical appraisal of conventional risk management approaches revealed that many of the conditions for the successful application of these approaches were not satisfied in Megaprojects; in particular, problems arose from incomplete, insufficient and inaccurate data as well as lack of experts. These constraints severely limit the capability of conventional methods to manage risks in Megaprojects to the extent that these methods might not produce meaningful and realistic results. The chapter has also revealed that, despite the contribution of academic studies to risk management research over the last 20 years, there is a dearth of studies that have attempted to investigate MCRs. This chapter has critically proved the need for a new risk management approach in Megaprojects, one that is able to cope with the scale and complexity of this sort of project, which will ultimately address the knowledge gap.

Chapter 4 Derivation of Theoretical Constructs of the Proposed Approach

4.1 Introduction

Chapter 2 demonstrated that Megaproject Risks (MRs) are significantly different from risks in conventional projects, resulting in the cancellation, serious delay and cost overruns of many Megaprojects [23]; hence, MRs need to be managed and mitigated differently [24]. Additionally, Chapter 3 showed that conventional risk management approaches are inadequate to address the MRs, which justifies the need for a new approach to risk management for Megaprojects beyond conventional approaches [41, 180, 183]. Based on these two chapters, the research problem is articulated in Section 1.3, which is translated into three research questions: Is there a better way to improve risk management in Megaprojects beyond the existing conventional approaches? What are MCRs? Is there a better way to think about MCRs? To answer these research questions, an inductive research approach is needed to derive conceptual insights, especially when there is limited theoretical knowledge about a particular phenomenon like Megaprojects [47, 184, 185]. The purpose of the current chapter is to theoretically derive an approach to address the research problem while improving the risk management of Megaprojects. The chapter is built upon the theoretical foundation provided in the two previous chapters, to present and justify the synthesis of theoretical concepts/constructs and fundamental principles that underpin the development of a proposed approach to risk management for Megaprojects. The chapter consists of six sections, including this introduction. Section 4.2 briefly outlines the steps of the theoretical derivation of mitigation measures that are critical to Megaprojects (CMMs). Section 4.3 provides a detailed definition of MRCs. Section 4.4 provides a detailed definition of CMMs. Section 4.5 presents and discusses the synthesis of theoretical concepts that underpin both MCRs and CMMs as fundamental elements for the theoretical development of the proposed approach to risk management in Megaprojects. Lastly, Section 4.6 summarises the chapter.

4.2 Theoretical Derivation of Critical Mitigation Measures for Megaprojects

In order to theoretically develop an approach for the current research study, there is a fundamental need to identify and define MCRs and the possible mitigation measures that are critical to Megaprojects (CMMs). The study also argues that identifying, defining and integrating both MCRs and CMMs can form a coherent common approach of risk management for all Megaprojects. Therefore, in the pre-fieldwork study phase, a rigorous literature review was carried out to identify a comprehensive list of recommended mitigation measures for Megaprojects, as shown in Figure 4.1. Producing such a comprehensive list was used as the main source to extract and consider CMMs. Therefore, the comprehensive list was screened into a shortlist of CMMs by evaluating each recommended mitigation measure against a set of selection criteria as well as a set of success indicators. The selection decision was made by the researcher by breaking down each mitigation measure into a number and elements and analysing these individually. The following sections discuss the two stages of the adopted procedure to derive CMMs.

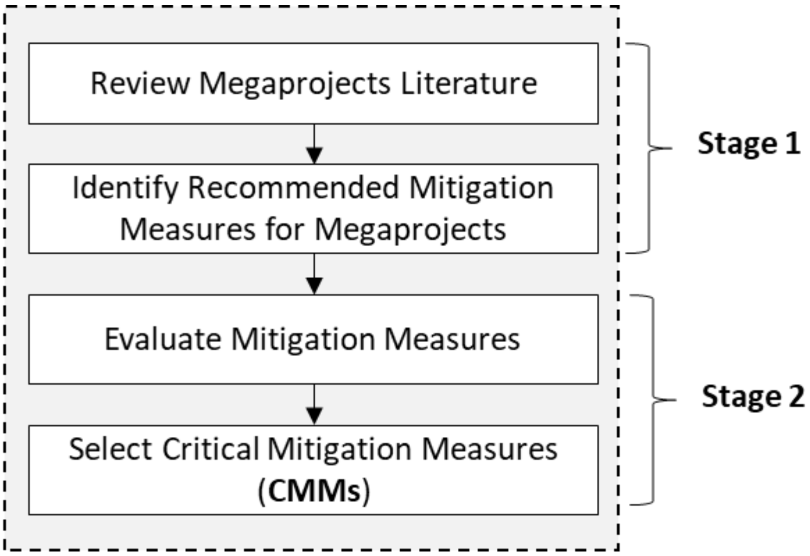

Figure 4-1 Theoretical Derivation of Critical Mitigation Measures for Megaprojects

4.2.1 Stage 1 – Identification of Recommended Mitigation Measures for Megaprojects

This section aims to identify a comprehensive list of recommended mitigation measures for Megaprojects from literature. To the best of the author's knowledge, there has so far been little effort in both research and practice to systematically identify a comprehensive list of mitigation measures for managing risks in Megaprojects [81]. Hence, the delivery activities of Megaprojects, which are exposed to different types of risks than conventional projects, maybe partly neglected, if not totally, and without proper management. However, this claim does not refute the contribution of other researchers in a particular aspect of risk management for Megaprojects, such as risk identification, risk analysis, or risk allocation.

For example, Greiman [41] in her book recommended important lessons to be learned to overcome the difficulties in managing and delivering future Megaprojects over their life cycle. For example, she suggested the need for a shared vision, partnering, and an integrated structure to mitigate and eliminate the enormous risk potential that is not usually present in conventional projects. Lam [23] provided a sectoral review of mitigation measures to cope with risks associated with infrastructure Megaprojects. He reported that government guarantees are required as a mitigation measure to reimburse concessionaires for traffic volume shortfall, foreign exchange and interest rate losses associated with risk aspects in bridge, tunnel and airport Megaprojects. Miller and Lessard [134] outlined ranges of strategies for coping with risks and turbulence in Megaprojects based on an assessment of 60 Megaprojects. For example, they pointed out that, when risks are poorly defined but at least partially under the control of affected parties, governments or regulators, transforming them through institutional influence is the way for sponsors to gain some control. However, the key limitation with Miller and Lessard [134] study is that the response strategies could be interpreted differently by practitioners.

Davies *et al.* [186] provided five suggestions (rules) to manage the uncertainties across all large-scale, long-term projects — not just projects with billion-dollar budgets. For example, they reported that a selective flexibility contract approach that creates different contracts and collaborative arrangements could act as a mitigation measure to address the varying challenges of individual packages within a Megaproject. Biesenthal *et al.* [187] provided examples of institutional arrangements adopted in Megaproject case studies as measures to manage this sort of project. For example, they reported on how the London 2012 Olympics set up two bodies, the Olympic Delivery Authority and a joint venture between contractors, to create a delivery partner to deliver venues and facilities. These authors also reported another example when a cost-plus contract as a mitigation measure that established collaborative rules for the working of an integrated project team was used in the Heathrow Terminal 5 Megaproject. For example, they suggested that adaptive problem-solving capabilities are needed by establishing project team structures and processes to deal with emergent problems and opportunities in Megaprojects.

Sergeeva and Zanello [188] explored the role of innovation champions, and the ways innovation is championed and promoted in Megaprojects. For example, they reported that early involvement of the delivery partner and contractor in the London 2012 Olympics was used as an approach to manage and mitigate risks associated with innovation. Mišić and Radujković [149] identified critical success factors that can affect Megaproject success or failure. For example, they reported that the awareness of and compliance with rules and regulations are among the critical success factors which could act to mitigate risk associated with Megaprojects. Miller and Hobbs [189] provided a list of primary lessons for better management of complex Megaprojects. For example, they suggested that Megaproject development requires a rich and varied pool of strategic resources and the flexibility to adapt to emergent situations. Wang *et al.* [119] identified specific mitigation measures for risk associated with international construction projects, particularly in developing countries, rather than generic mitigation measures that can be applied to all Megaprojects irrespective of where they are located. Zeng *et al.* [190] proposed specific risk mitigation strategies for water supply Megaprojects under the Build Operate Transfer Scheme (BOT) in China rather than a generic list for all Megaprojects. Guo *et al.* [81] addressed the effects of project governance structures on the management of risks in infrastructure Megaprojects. Marques and Berg [191] identified mitigation and minimisation measures for risk reflected in regulatory infrastructure contracts.

Despite the contributions of the above studies to managing and mitigating MRs, there are some limitations. For example, some of these studies are based on case study methodologies, such as the contributions of Greiman [41] and Sergeeva and Zanello [188], which are based on the Big Dig and London 2012 Olympics respectively. However, case study methodology is primarily narrative with evidence which is largely embedded in individual case contexts [192], thus generalising its outcomes would not be true for all other cases. The other limitation of the above studies is their outcomes are only designed for a specific Megaproject context, such as the contributions made by Zeng *et al.* [190], Wang *et al.* [119], or Zeng *et al.* [190]. Again, generalising the outcomes of such studies could also mislead both practitioners and academics in Megaprojects. Therefore, and based on the above limitations, it can be argued that there is a dearth of studies that investigate and/or produce a comprehensive list of measures for managing and mitigating risks in Megaprojects, which could be attributed to several reasons.

Among the reasons behind the lack of producing a comprehensive list of mitigation measures in Megaprojects, is the variety of risk response strategies, which are avoidance, mitigating, transfer and retaining [102, 125]. Further, the risk could be fully mitigated, partially mitigated, or unmitigated by a particular mitigation measure; hence it is difficult to produce a generic list of mitigations. In fact, risk cannot always be mitigated or controlled, but it can be assessed and or allocated if it is commercially reasonable [193]. Moreover, the risk could be mitigated differently, either by reducing the magnitude of the consequences of the event (assuming that the event has occurred) or by reducing the likelihood (expected frequency) that the event could occur or both [72]. The other possible reason is managing and mitigating risk depends on the perceptions, attitudes and experiences of Megaproject experts and practitioners, which can add more challenges in developing a generic list of mitigations [97]. This is also connected to the fact that risk could be managed and/or mitigated by an unlimited number of mitigations based on the influence and cost-benefit ratio since management risk certainly is not cost-free [194]. The other possible reason is risk mitigation could be manifested differently, i.e. a risk could be managed contractually, technically, legally, or commercially. Finally, risks are constantly changing and evolving [195]; hence mitigation measures are evolving too [67], which can also add more challenges in generating a comprehensive list of mitigation measures.

The above argument underlines that any risk could be manifested in many different ways, and it can have many factors and triggers, which eventually cascade into problematic effects [30, 68]. This conveys the clear message that no single mitigation measure can solve the whole problem and accordingly encourages a holistic approach [24]. The existing literature also underlines that using a comprehensive literature review is widely acceptable and applicable as an identification tool; hence, it is adopted in this research study. This is supported by Simm and Cruickshank [128], who argued that risk mitigation measures could be identified using similar techniques to those used initially to identify risks.

Many researchers have utilised a literature survey to identify mitigation measures, success factors, best practices and lessons learned, which eventually could potentially help to manage and mitigate project risks [196-199]. For example, Serpell *et al.* [200] conducted a comprehensive literature review to understand how risk management is carried out worldwide in the construction industry. Similarly, Shankar Kshirsagar *et al.* [201] conducted a comprehensive literature review to identify issues, best practices and implementation of life cycle cost analysis in all construction projects. Warrack [202] researched the literature to summarise five lessons to be learned from Megaproject experiences in Western Canada in order to improve the process of the decision-making process in Megaprojects. Jaafari [203] also researched the literature to identify typical risk variables associated with construction projects and their conventional treatments and mitigations. Di Maddaloni and Davis [204] synthesised their literature review to identify significant assumptions on the influence of stakeholders in Public Infrastructure Megaprojects. Ahmed [198] also used the literature review in order to investigate risk mitigation strategies in innovative projects, including the lessons learnt from previous similar projects to handle project risk.

Therefore, for the current research purposes, a comprehensive literature review survey is adopted to identify a comprehensive list of recommended mitigation measures for Megaprojects by covering a wide range of literature including journal papers, case studies, lessons and best practices, official documents and technical reports by international organisations. A literature review is adopted because it enables access to databases with good insight into many aspects of risk management like multiple paradigms, perspectives, methodologies and streams of enquiry [205].

In the current research study, a systematic identification approach is used to identify recommended mitigation measures for Megaprojects. The systematic approach is based on the content analysis method and consists of three steps [100]. Step 1 (preparation), which involves selecting the unit of analysis and the database. Step 2 (organising), which involves coding and creating categories. Step 3 (reporting), which involves reporting the analysis process results with sufficient details.

For Step 1 (preparation), the relevant documents about risk management in Megaprojects is the selected unit of analysis. The reason for this choice is that analysis of the content of what is published reveals what is thought important and disseminated [206]. The content of material published on how to manage and mitigate risk normally reflects what is important, significant, frequent, and up to date regarding the Megaproject delivery performance. Therefore, to find such material, three steps were conducted to refine and screen the data, namely: database selection, keyword selection, and source of information selection. The rationales behind these three steps are provided as follow.

For database selection, the Google Scholar search engine is utilised to identify relevant published materials on managing and mitigating risk in Megaprojects. The rationale behind this decision simply because Google Scholar retrieves data from a variety of resources, and it encompasses a wide range of non-traditional academic sources [207]. This verity of sources helps the researcher to gain diverse knowledge about managing and mitigating risks in Megaprojects from both academic and non-academic sources.

In the preparation step, three groups of keywords are used in the search engine. The first group is used to indicate Megaprojects, and these are “complex Mega-projects”, “large-scale projects”, “large engineering projects”, “major projects”, “complex projects”, “giant projects”, “jumbo projects” and “Megaprojects”. The second group is used to indicate risk mitigation measures, and these are “risk mitigation”, “risk-mitigating”, “risk response”, “risk reduction”, “risk minimising”, “risk alleviation”. Because there is a variety of mitigation measures terms, the third group includes “approaches”, “strategies”, “measures”, “methods”, “tools” and “actions”. The Boolean “OR” is used between the keywords of the first group to ensure that at least one term must appear in the search. It is also used in the second and third groups for the same reason. The Boolean operator “AND” is used between the terms in the three groups to ensure that all possible keywords appear. For example, “Mega-projects” OR “large-scale projects” AND “risk-mitigating” OR “risk response” AND “approaches” OR “strategies” is a typical search attempt. At this stage of the search, and according to the selection of the key common words, hundreds of documents appeared in the search results.

Given the wide spectrum and coverage of studies on risk management for Megaprojects, it would still be difficult to identify the most important measures for managing and mitigating risks in Megaprojects. The key reason behind this argument is risk mitigation relays a clear perception of the risks being borne by each party [208]. Further, the mitigating risk could be manifested differently, i.e. a risk could be managed and/or mitigated contractually, technically, legally, or commercially. Therefore, in terms of the source of information selection, the focus of the current review was on only relevant documents. Therefore, in Step 2 (organising), the documents that appeared in the search results were read through skimming and scanning technique in order to screen those relevant to manage and mitigate risks in Megaprojects. The actual selection of the relevant material for inclusion in the “organising” Step 2 was dependent upon the researcher’s decision after reading the article abstract and title to a similar way that has been followed by Finney and Corbett [209] in their study.

The organising step which involves coding and creating categories. Based on the initial filter, only 32 relevant documents then were carefully read through to identify any measure, action, or method that could potentially help to manage and to mitigate MRs and affect the delivery performance of Megaprojects. Once a recommended mitigation was identified from the document text, a code (name) was developed to link that measure in the document. A list of measures (codes) was then provided for each document and printed out for use in the categorising stage. It should be noted that one of the challenges in the coding stage was extracting mitigation measures that are not explicitly mentioned in the text, which was subjected to the researcher's interpretation of the text. The possible reason behind this challenge is a mitigation measure could be manifested and expressed differently based on risk perception of the authors, experts, or practitioners [97].

To illustrate the coding process, the paper of Lam [23] for example, was downloaded and printed out in order to be manually investigated by the main researcher. It was found that, in this particular document, the author provided and reported summary tables of risks associated with different sectors of Megaprojects and their recommended mitigation measures. In this document, the author reported that the construction contracts were designed to control the cost of the Channel Tunnel Megaproject (HS1), between Britain and France [23]. The author also reported that that target price contract was used for the tunnelling whereby contractor would be rewarded for keeping cost below target or penalised for excess, whereas lump sum model was used for the terminal works [23]. Thus, this mitigation measure was coded under the code "contractual mitigation measures" because it is explicitly reported as a mitigation measure straightway, and it is associated with contractual arrangements. Another coding example can be illustrated in the work of Davies *et al.* [186]. These authors reported that the Olympic Delivery Authority used flexible contractual approach in the planning of the London 2012 Olympics. This action is understood by the researcher as a mitigation measure and thus was coded under the code "selectively flexible contract" because it provides flexibility in the contractual arrangements to manage project risks in this Megaproject example.

Once the codes were identified, and the coding process was completed, codes that contributed to the same meaning were grouped under a single category. For example, the above-mentioned codes "contractual mitigation measures" and "selectively flexible contract" were grouped into a broad and meaningful category, namely "New Form of Contract". The rationale behind this decision is these two codes are contractual mitigation measures, and both reflect the need for a new form of contract for Megaprojects. The categorising process was repeated until distinct sets of categories were obtained, where each category represents a distinctive mitigation measure. At the end of "categorising" step, ten unique categories were formulated in the "reporting" step as recommended mitigation measures for Megaprojects, which are then defined and described in Table 4.1. The sources and references used to reach this comprehensive list of recommended mitigation measures are also listed in Table 4.1.

Table 4.1 lists a summary of the identified recommended mitigation measures extracted from Lam [23], Greiman [41], Miller and Lessard [51], Guo *et al.* [81], Awwad *et al.* [110], [119], Project Management Institute [131], Miller and Lessard [134], Allport [137], Mišić and Radujković [149], Davies *et al.* [186], Biesenthal *et al.* [187], Sergeeva and Zanello [188], Miller and Hobbs [189], Zeng *et al.* [190], Marques and Berg [191], Gentle [194], Grabowski and Roberts [197], Ahmed [198], Al Khattab *et al.* [210], Alsadeq [211], Chartered Institute of Building [212], Dubai Government [213], Floricel and Miller [214], Gann *et al.* [215], Global Infrastructure Hub [216], Grimsey and Lewis [217], Maniruzzaman [218], Nolan *et al.* [219], Oliveira *et al.* [220], Stiller [221], Treasury [222], World Economic Forum [223], World Economic Forum [224]. Accordingly, the recommended mitigation measures listed in Table 4.1 can be used as a comprehensive source to extract and consider a set of CMMs that can be applied across all Megaprojects.

Table 4-1 Recommended Mitigation Measures for Megaprojects

No	Measure	Definition	References
1	Project Management Office	An organisational body at the national level assigned various responsibilities related to the centralised and coordinated management of those projects under its domain. The responsibilities of the PMO can range from providing project management support functions to actually being responsible for the direct management of a project.	[41, 81, 131, 137, 149, 186, 188, 189, 211, 212, 218-220, 222, 224]
2	New Form of Contract	A new form of the contract specifically for the Megaprojects context to accommodate some flexibility and adaptability principles to tackle the issues of non-linearity or scaling-up of Megaprojects.	[23, 110, 186, 187, 189, 191, 198, 211, 215, 217, 219, 220]
3	Dispute Resolution Mechanisms	A dispute mechanism is a structured process that addresses disputes or grievances that arise between two or more parties engaged in business, legal or societal relationships.	[110, 187, 188, 191, 216, 217, 219-223]
4	Act of Parliament	These are statutory instruments that could potentially accommodate provisions to provide protections against non-commercial risks such as unexpected changes in	[23, 190, 194, 210, 213, 216,

No	Measure	Definition	References
		legalisation and policies, and allowing compensation to cover the associated costs.	218, 221, 223]
5	Special Purpose Vehicles	An SPV is simply a separate legal entity; generally, a company, established to undertake the activity defined in a contract between the SPV and its client, in this case, the public procurer. Execution of the activity generally requires the involvement of a number of parties, and the SPV enters into subcontracts with a number of organisations for the execution of these activities.	[23, 41, 51, 131, 198, 213, 214, 217, 223]
6	Political Risk Insurance	Political Risk Insurance can be defined as a financial instrument that transfers certain defined risks to a creditworthy third party (guarantors and insurers) that has a better capacity to accept such risks. It can be purchased from three types of providers: public providers, private providers and reinsurers. This strategy could help mitigate and manage risks associated with adverse actions and omissions by a host government.	[41, 190, 194, 210, 217, 221, 223, 224]
7	Code of Practice	Codes provide a consistent approach to plan, manage and deliver Megaprojects across a wide range of key stakeholders by providing them with best practices, processes and procedures specifically designed for Megaprojects. This can help practitioners to understand the scale and risk of Megaprojects; hence, to manage and mitigate them in a better way.	[41, 51, 131, 149, 187, 212, 220]
8	Investment Agreement	The basic idea of all investment agreements is to protect the foreign investment from arbitrary governmental actions, by defining a standard set of investor-protection clauses and opening the way to international arbitration in the event of disputes.	[186, 197, 218, 221, 223, 224]
9	Bilateral Investment Treaties	These measures oblige a host government to compensate foreign investors in the event of an expropriation, regardless of whether the expropriation resulted from a direct act of taking, such as nationalisation, or an indirect taking that substantially deprived the investor of the use or enjoyment of its investment.	[110, 219, 223]
10	Project Initiation Routemap	This routemap is an aid to strategic decision-making designed by the Infrastructure and Projects Authority (IPA) to support the alignment of the sponsor and client organisation's capability in order to meet the degree of a challenge during initiation and delivery of Megaprojects, such as the lack of effective engagement with stakeholders.	[131, 214, 222]

4.2.2 Stage 2 – Identification of Critical Mitigation Measures

The current section aims to identify a set of mitigation measures that are critical for Megaprojects (CMMs) as fundamental elements of the proposed approach to address the research problem. Therefore, this section proposes a qualitative process to select CMMs by screening out the comprehensive list of recommended mitigation measures for Megaprojects identified in the previous section – listed in Table 4.1. The proposed process consists of four steps. The first step involves defining what constitutes CMMs by classifying mitigation measures in Megaprojects. The second step involves specifying a set of selection criteria from the literature. The third step involves evaluating each recommended mitigation measure for Megaprojects against the set of selection criteria that distinguish between generic and non-generic mitigation measures. The fourth step involves selecting CMMs. These steps are discussed in the following sections.

4.2.2.1 Step 1 – Defining Critical Mitigation Measures in Megaprojects

This step involves defining what constitutes CMMs. Ng and Loosemore [99] argued that project risk could be categorised into two categories: generic risk and specific risks, where the former can be managed with generic mitigation measures, and the latter can be managed with specific mitigation measures. In contrast, Oke and Gopalakrishnan [225] classified risk mitigation strategies into two broad groups: generic strategies and specific strategies, where the former could be applied to handle most risk types, and the latter could be applied for handling particular risks. Drawing from Ng and Loosemore [99] and Oke and Gopalakrishnan [225] concepts of classifying risks and mitigation measures respectively, mitigation measures for Megaprojects can be classified into generic mitigation measures that can handle MCRs and non-generic mitigation measures that can handle specific MRs. This classification seems to be in line with the classification proposed by Mashiko and Basili [226], who classified influential factors into two groups: first, influential factors common to all projects and, second, those specific to individual projects. It is also in line with the argument made by Clark [227], who stated that there are certain tasks or activities that are common to all projects, and others are not. Based on the above argument, CMMs can be defined in the current research study as the mitigation measures that are designed to be broadly applicable across all Megaprojects; hence they can be applied to effectively manage and/or mitigate systematic MCRs. For the current research purposes, the proposed definition of CMMs is used in the next step to identify and specify a set of selection criteria for evaluating the identified mitigation measures in Stage 1 and listed in Table 4.1.

4.2.2.2 Step 2 – Specifying Selection Criteria

This step focuses on specifying appropriate selection criteria against which the recommended mitigation measures for Megaprojects will be evaluated. For the current research purposes, the literature review was conducted to identify and specify the selection criteria of CMMs based on the proposed definition in Step 1. The rationale behind this decision is most of relevant criteria of what constitute good mitigation measures are well documented in the literature by both academics and practitioners.

The literature shows that a mitigation measure is defined as any action that could potentially help to manage and/or reduce the adverse impact and/or probability of a risk to an acceptable level [71, 127-129]. Due to the fact that risk could be fully mitigated, partially mitigated, or unmitigated, the extent to which risks are controllable and the degree to which risks are specific to the project are critical factors to be considered in identifying mitigation measures [66]. The effect of a mitigation measure clearly depends on its specifications as well as on the risks to be managed; thus the impact of mitigation measures could be broadly classified into two groups: mitigations with direct impact and mitigations with indirect impact [228]. Qazi *et al.* [108] added that, in order to identify critical risks and select optimal risk mitigation strategies, the complexity attributes need to be linked to different trails of complexity-induced risks.

Moreover, the expected costs of risk mitigation measures and the uncertainty factors of the expected costs are other factors that need to be considered and assessed to check the feasibility of the project [148, 229]. For example, Zuo and Zhang [229] used a cost-effectiveness approach as an objective, which aims to minimise the difference between the upper bound mitigation cost/risk ratio and the mitigation cost/risk ratio generated from the project. Given the fact that risk could be managed and/or mitigated by an unlimited number of mitigations, certain mitigation measures can also mitigate more than one risk simultaneously [230]. This is also supported by Qazi *et al.* [108], who argued that a strategy or combination of strategies could have a positive correlation with a risk or multiple risks. For example, Wang and Tiong [231] reported that insurance could reduce and mitigate several risks in BOT projects such as Force Majeure risk or construction risk.

The above argument underlines that the features of effective mitigation measures can be summarised into four elements. The first element involves the ability of the measure to reduce the frequency of risk causes, eliminate some of the risk causes, reduce the frequency of consequences, or reduce and/or mitigate consequences [102, 121]. The second element involves the practical reliability of the measure to overcome practical difficulties that arise when attempting to apply that measure in practice [232, 233]. Thus, the mitigations should provide a practical and rational approach to the process of managing risk in projects [102]. The third element involves the ability of the measure to manage and/or mitigate multiple risks collectively [108]. Fourth, measures must be financially reasonable to manage and/or mitigate risks where the remaining risks are not critical to the project [93].

For the current research's purposes, the first three features are considered as a set of selection criteria to evaluate the comprehensive list of recommended mitigation measures. The rationale behind this decision is the evaluation process for each recommended mitigation could be performed using the existing literature review. However, because the cost-benefit analysis for potential mitigation measures should be carried out on a case-by-case basis [90], the fourth feature (mitigation cost/risk ratio) is not considered in the selection criteria. Therefore, the proposed selection process has a limitation that only three criteria can be considered. Accordingly, these criteria are used in the next step to qualitatively evaluate the comprehensive list of recommended mitigation measures as shown in Table 4.2.

4.2.2.3 Step 3 – Evaluating Recommended Mitigation Measures

This step aims to evaluate the comprehensive list of recommended mitigation measures for Megaprojects against the selection criteria. Therefore, the selection criteria that have been extracted in the previous step were used to evaluate the recommended mitigation measures that have been identified in Stage 1 and presented in Section 4.2.1. To support this step, the literature was reviewed to collect relevant information about each recommended mitigation measure with respect to its applicability to reduce MCRs' probability and/or impact, its practical reliability, and its ability to manage and/or mitigate multiple MCRs. This process involves reviewing published literature and other documentation to Megaprojects using two sets of keywords in the Google Scholar search engine. The first set of keywords relates to the mitigation measures, whereas the second set of keywords relates to the selection criteria. For each research attempt, the first set of keywords is variable because it is created specifically to a particular mitigation measure. Whereas, the second set of keywords is constant for each research attempt since it is applicable to the selection criteria; hence it is applicable to all mitigation measures. For example, "statutory instruments" OR "Act of Parliament" AND "Megaprojects" OR "major projects" AND "risk reduction" OR "risk mitigation" OR "risk alleviation" is a typical search attempt to collect information about the Act of Parliament with respect to its applicability as a mitigation measure to reduce the probability and/or impact of MCRs. These research attempts helped the researcher to retrieve relevant literature and extract data to build arguments and support it for all recommended mitigation measures against the selection criteria, as shown in Table 4.2. By doing so, the researcher was enabled to evaluate each recommended mitigation measure for Megaprojects and provide an argument. The arguments presented in Table 4.2 were used in the next step to provide the rationales behind the deviation of CMMs.

Table 4-2 Evaluating Recommended Mitigation Measures against Selection Criteria

Mitigation Measure	Selection Criteria		
	Applicability to Reduce MCRs' Probability and/or Impact	**Practical Reliability**	**Ability to Manage and/or Mitigate Multiple MCRs**
Act of Parliament	Statutory instruments could potentially reduce the probability and/or impact of unexpected changes in legalisations and policies through a number of measures. First, by accommodating provisions that could provide protection against such risks [218, 234]. Second, by allowing compensation to the private sector in order to cover costs associated with such risks and stabilise the delivery environment for Megaprojects [218, 234].	Enacting a specific Act of Parliament for Megaprojects is practically applicable since this concept has been applied by many other countries as an effective mitigation measure to manage different types of risks in Megaprojects. For example, the Major Events Management Act 2007, is a statutory instrument that provides protection to organisers and sponsors of major events from ambush marketing and applies to any event that meets its criteria in New Zealand [235].	Because statutory instruments stabilise the regulatory and political environment of Megaprojects [223], these have the potential to manage unexpected changes in legalisations. Further, statutory instruments can practically ensure the right of the private party to obtain compensation due to unforeseen political circumstances [216]. Thus, these instruments could potentially help to align the expectations of stakeholders who are affected by unexpected legalisation changes [236].
Political Risk Insurance	Although political risk insurance may provide an important source of liquidity that could help cover certain costs following unexpected changes to legislation or policies, the insurance premiums are very high and expensive due to the capital-intensive nature of Megaprojects [237].	Although political risk insurance is effective in managing extreme actions against Megaprojects, in practice, however, developing such measures is practically challenging, which provides limited coverage for MCRs [238]. Further, political risk insurance is more sensitive to the geopolitical circumstances where Megaprojects are developed and delivered [239]. Therefore, it would seem that such measures are not generic to Megaprojects.	Political risk insurance covers actions taken by governments – actions that are less within the control of the private sector [240]. Accordingly, it can be argued that political risk insurance can be significantly influenced by the allocation of risks among the key stakeholders. Thus, it can be argued that this measure can affect Megaprojects differently; hence it is inappropriate to consider it within the CMMs.
Bilateral Investment Treaties	BITs generally aim to promote and strengthen investment relations between countries [241]. Therefore, BITs are more	Although in some cases BITs can afford foreign investors some protection against unexpected changes in legislation and policies such as	BITs as mitigation measures can only affect Megaprojects that have a mutual element between the two countries of a particular

Mitigation Measure	Selection Criteria		
	Applicability to Reduce MCRs' Probability and/or Impact	Practical Reliability	Ability to Manage and/or Mitigate Multiple MCRs
	suitable to provide absolute protection from unlawful expropriation, the right to fair and equitable treatment, full protection and security, and free transfer of funds [223]. None of these protections can manage and/or mitigate any part of MCRs.	expropriation [242], it is unnecessary for all Megaprojects to rely on foreign investors for the development and delivery processes. Therefore, the BIT is practically inapplicable for all Megaproject; hence it is excluded from the generic mitigation measures package.	BIT [223]. Thus, BITs are a typical example of non-generic mitigation measure to Megaprojects; hence not corresponding to any element of MCRs.
Project Management Office	The role of the PMO as the main facilitator and coordinator of Megaprojects can help both internal and external stakeholders to identify, articulate and communicate their strategic objectives clearly from very early stages [243]. Hence, the PMO can provide better directions for stakeholders' engagement from the outset, and this can reduce the probability and impact of conflicts, disputes and misalignment [244, 245]. The other significant value of the PMO is about bringing together all stakeholders, building a relationship, understanding people and facilitating proper conversation at the appropriate time.	Developing the PMO at the national level is practically applicable, which has been applied in many other countries. For example, the Paraguay Project Management Office (PPMO) is an example of a PMO at the national level, which resulted from the country's need to professionalise its project execution through the development of a new management model and to strengthen its institutional capacity in the mid-term [224]. QNPM is another example, which is a planning council initiative to build and support professional project management capacity in Qatar's public service [211].	The PMO can play a fundamental role to improve the stakeholders' alignment; hence improve the delivery of Megaprojects [78]. Authors argue that having a central PMO can also influence project operation; hence manage and mitigate the risk of lack of operability of Megaprojects [246]. The rationale behind this argument is that the PMO, as the main facilitator and coordinator, can help to ensure and codify the engagement of expertise in Megaproject operation at very early appraisal phases [247]. Thus, the PMO can manage and mitigate more than MCRs.
Code of Practice	It can be argued that mandating a **code of practice** can help practitioners to manage and reduce the probability of scaling-up risks inherent in Megaprojects. The rationale behind this argument is that the scale of Megaprojects is a major source of risks, which makes all Megaprojects involve major	Developing a specific COP for Megaprojects is practically applicable in the UK context. A range of guidebooks, codes of practice and protocols have been produced to assist practitioners in managing their conventional construction projects compared to Megaprojects. Also, the approach will enhance the capabilities of	Developing a comprehensive code of practice specifically for Megaprojects has the potential to manage scaling-up risks; hence improve the delivery of Megaprojects [129]. Further, compliance with COPs can also create a line of consistency and recognition of best practices to be

Mitigation Measure	Selection Criteria		
	Applicability to Reduce MCRs' Probability and/or Impact	**Practical Reliability**	**Ability to Manage and/or Mitigate Multiple MCRs**
	elements, packages, processes and systems [248]. These major components are often associated with untested and unproven technologies, which often incorporate many technical risks and uncertainties [92]. Further, having a dynamic COP makes it more suitable to reactively address scaling-up issues in Megaprojects simply because best practices may be applicable only in certain circumstances, which can change dramatically and rapidly in the Megaprojects environment [6].	existing tools such the over 30 risk management techniques contained in the British Standards codes of practice (BS 31100:2008 Risk management – Code of practice; BS ISO 31000:2009 Risk management – Principles and guidelines, and BS EN 31010:2010 Risk management–Risk assessment techniques) during risk management.	accommodated into the contractual arrangements of Megaprojects at different organisational levels. The operability can also be managed through the COP by accommodating a clear and separate chapter about the importance of selection and involvement of a senior operator with an economic interest in enhancing revenues and controlling operational costs at a very early conceptual design stage.
Dispute Resolution Mechanisms	Dispute resolution mechanisms in the project finance context are a means of enforcing the allocation of risks among a project's many participants – sponsors, lenders, contractors and subcontractors, service providers, off-take-purchasers and others. To the extent that a dispute resolution mechanism is swift, flexible, reliable, final and enforceable, the project's intended allocation of risks can be maintained [249].	Dispute resolution methodologies are practically applicable in Megaprojects, which should be designed to encourage conflict avoidance and dispute prevention before controversies escalate and cause serious communication breakdowns among the key stakeholders [41]. However, dispute resolution mechanisms were increasingly perceived as being ineffective [250] and bring barriers to smooth Megaproject implementation.	Although dispute resolution methodologies could help managing disputes among stakeholders in Megaprojects, these are not necessarily able to align the expectations of the disputed parties [251]. Furthermore, these methodologies are mainly designed to manage risk associated with contractual arrangements rather than other types of MCRs.
Investment Agreement	An investment agreement can help establish a reliable contracting environment and may foster foreign investment [252]. Thus, such agreements have the potential to reduce the probability and/or impact of risk associated with financial arrangements. Because not all	The basic idea of all investment agreements is to protect the foreign investment from arbitrary governmental actions, by defining a standard set of investor-protection clauses and opening the way to international arbitration in the event of disputes [223]. However, it should be noted that	Investment agreement methodologies are designed to facilitate foreign direct investment [241]. Therefore, these methodologies are more suitable for managing and mitigating risk associated with Megaprojects under PPP schemes

Mitigation Measure	Selection Criteria		
	Applicability to Reduce MCRs' Probability and/or Impact	**Practical Reliability**	**Ability to Manage and/or Mitigate Multiple MCRs**
	Megaprojects are funded and/or financed by foreign investors, this measure is not generic to all Megaprojects [160].	Megaprojects might be funded entirely by the public sector or the private sector. Therefore, it would seem that the Investment Agreements are not generic to Megaprojects.	rather than MCRs [253]. Therefore, this mitigation measure is not considered generic to Megaprojects.
New Form of Contract	Incompleteness is inherent in the contractual systems and arrangements of all Megaprojects compared with conventional construction projects, mainly due to the turbulent, lengthy life cycle [64] and scale of scope [197]. Developing a new form of contract specifically for Megaprojects could potentially help to manage incomplete contracts by procuring different project packages in a concurrent way to reduce the risk of interfaces [67, 203]. Therefore, it can be argued that having an appropriate contract system can increase the level of flexibility needed to reduce the probability and/or impact of incomplete risks in Megaprojects.	Further, given the scale of Megaprojects, managing them inevitably involves designing contracts between the project owner and one or more specialised contractors [254]. Further, contractual arrangements can shape the behaviour of the parties involved in the project [255]. Due to the inherent nature, contractual arrangements of Megaprojects are featured as long term, incomplete and complex [6]; therefore, under such a context, the contract plays a crucial role in managing Megaprojects [254].	Developing a new form of contract for Megaprojects can manage and mitigate more than MCRs. For example, the first possible MCR is the mitigation of incomplete contract by incorporating the collaborative behaviours and incentivising shared outcomes schemes, both of which can also contribute towards improving the contractual arrangements in Megaprojects [110, 134]. Further, practitioners tend to manage and mitigate risks associated with scaling-up by allocating them contractually to the party best able to handle them [41, 256].
Project Initiation Routemap	The use of such modules can ensure that the project solution is defined, developed, constructed and handed over appropriately. It is also associated with a number of weaknesses and limitations when it is applied to Megaprojects [257]. Therefore, this measure has the potential to reduce the probability and/or impact of risks associated	The first issue with this routemap is as an advisory document since it provides advice on how to structure and manage stakeholders in Megaprojects [257]. Further, the routemap is a not a live document but a static one, i.e. there is no frequent update to it, which is not suitable to cope with the dynamic nature of Megaprojects [67]. This underlines that this routemap is not	Although the IPA routemap provides a good link between the project and the organisation's strategic priorities, it can mainly help in managing risks associated with project initiation rather than MCRs. For example, the application of an assets management module helps to ensure that the project not only delivers working assets

Mitigation Measure	Selection Criteria		
	Applicability to Reduce MCRs' Probability and/or Impact	**Practical Reliability**	**Ability to Manage and/or Mitigate Multiple MCRs**
	with selecting and choosing the appropriate Megaprojects to develop.	practically applicable for Megaprojects; hence it is non-generic to Megaprojects.	at handover into operations but sustainable, longer-term benefits and managed asset risks through the life of those assets [257].
Special Purpose Vehicles	International projects often result in complex contractual finance mechanisms with the establishment of a 'Special Purpose Vehicle' (SPV) arrangement to allow operating contracts with key participants to be agreed [258]. The enhanced cooperation behaviour of the SPV can mainly manifest in improving the management level, which can also give the government extra benefits (e.g., the risk and cost reduction caused by the smooth implementation of the project) [259].	Although most Megaprojects might involve organisations called Special Purpose Entities (SPEs) also known as Special Purpose Vehicles (SPVs) to meet specified requirements of the client [260], the structure of these SPVs is mainly influenced by a number of factors including the number and diversity of stakeholders, financial model, shareholders' agreement and contractual arrangements [99, 261]. Collectively, these influential factors can make the influence of SPVs vary from one Megaproject to another; hence it is non-generic to all Megaprojects.	A Special Purpose Vehicle (SPV) created to deliver the project controls the risk of design, including deficiencies in the design process and final drawings [256]. It is an entity responsible for raising funds, making a payment, delivering the agreed service, and ensuring the asset is well maintained through the concession period [262]. Therefore, this mitigation measure is not considered generic to Megaprojects.

4.2.2.4 Step 4 – Deriving Critical Mitigation Measures

In the previous step, all recommended mitigation measures were evaluated against the selection criteria, as shown in Table 4.2. The current step aims to derive and select mitigation measures that are critical to Megaprojects (CMMs) from the evaluated list of recommended mitigation measures in Table 4.2 in order to form the proposed approach to risk management in Megaprojects. To derive CMMs, a manual Qualitative Comparative Analysis (QCA) approach is adopted [263]. The QCA is the most formalised and widespread method making use of set-analytic thinking as a fundamental logical basis for qualitative case analysis [264]. QCA is widely used by many researchers in the area of project management. For example, Guo *et al.* [81] used the QCA method to investigate how different project governance structures affect the management of risk in infrastructure Megaprojects. Verweij [265] used the Multi-value QCA (mvQCA) approach to investigate how managers in public-private partnership (PPP) Megaprojects respond to social or physical events during the implementation of their projects. Boon *et al.* [266] also applied a similar comparative approach by comparing a set of critical success factors for Enterprise Resource Planning (ERP) against the literature. For the current research purposes, the QCA is adopted to rationales two decisions. The first decision is to determine whether the recommended mitigation measures for Megaprojects meet the selection criteria presented in the previous step. The second decision is to determine whether the recommended mitigation measures for Megaprojects could contribute to the success of Megaprojects.

Therefore, the information and data presented in Table 4.2 were used to provide some rationales behind the deviation process of CMMs. The arguments made in Table 4.2 enable the researcher to conduct QCA of the evaluation criteria between all recommended mitigation measures and get more insights on each measure. This is supported by Rihoux [267] who argued that QCA is an inductive technique, to the extent that it allows the researcher to discover more through a dialogue with the data. Therefore, the data presented in Table 4.2 eventually aids and supports the researcher’s judgment to determine whether the evaluation criteria are met by each recommended mitigation measures. This is also supported by Rihoux [267] who argued that QCA is a particularly transparent technique, insofar as it forces the researcher not only to make choices on his or her own but also to justify these choices, from a theoretical and/or empirical perspective.

It also can be seen from Table 4.2 that all the mitigation measures have some elements that could reduce the probability of occurrence and/or the adverse impact of different types of MRs. Table 4.2 also shows that some of the mitigation measures are practically applicable to Megaprojects and the others are not. It can also be seen that some but not all the mitigation measures have the potential to manage and/or mitigate MCRs. This underlines that the selection criteria are met differently between the recommended mitigation measures. For example, it can be seen from Table 4.2 that most of the features and elements of the Act of Parliament as a mitigation measure match the three selection criteria. Accordingly, the outputs of the QCA with respect to the evaluation of recommended mitigation measures against the selection criteria are summarised as statements in the second column of Table 4.3. Thus, the statements made in the second column of Table 4.3 can rationales the first decision of the derivation process of CMMs.

In addition to the evaluation of mitigation measures against the selection criteria, three success indicators reported by Locatelli *et al.* [268] – cost overrun, delayed in the planning phase, and delayed in the construction phase – have also been used in the QCA to support the derivation process of CMMs. Project success indicators are defined by Müller and Turner [269] as the measures by which the successful outcome of a project is assessed. This underlines that evaluating the recommended mitigation measures against the success indicators for Megaprojects that are adopted from Locatelli *et al.* [268] is a fundamental action to support the derivation process of CMMs. The rationale behind this argument is mitigation measures can be identified and designed to control, manage, and mitigate the impact of project risks, hence potentially improve the project delivery performance [176, 205].

Therefore, and similar to the previous step, the literature review was conducted to collect relevant information about each recommended mitigation measure with respect to the three success indicators adopted cost overrun, delayed in the planning phase, and delayed in the construction phase [268]. This involves reviewing published literature and other documentation to Megaprojects using the appropriate keywords in the Google Scholar search engine. For example, “Project Management Office” OR “National Governance System” AND “Megaprojects” OR “Large-Scale Engineering Projects” AND “cost overrun improvements” OR “time overrun improvements” OR “delay performance improvements” is a typical search attempt to collect information to investigate how Project Management Office as a mitigation measure can contribute to Megaproject success indicators. These research attempts helped the researcher to retrieve relevant literature and extract data for each recommended mitigation measures in Table 4.2 against three success indicators, as shown in the third column of Table 4.3.

The data in the third column of Table 4.3 helped the researcher to analyse it in order to determine which recommend mitigation measure that could contribute to the success indicators of Megaprojects. For example, if we take the PMO as an example, it can be seen that the significant value of PMO to Megaproject performance can be manifested by bringing together all stakeholders, building a relationship, understanding people and facilitating proper conversation at the appropriate time [245, 270, 271]. Therefore, having a PMO could reduce delays in both planning and construction phases and eventually cost overrun by applying bespoke methodologies for Megaprojects [272]. This example underlines that the PMO as a recommended mitigation measure has a strong link to the success indicators of Megaprojects, which can also rationalise the second decision of the derivation process of CMMs.

Table 4-3 Qualitative Comparison of Mitigation Measures and Literature

Mitigation Measures	Matching Selection Criteria	Megaproject Success Indicators	Discussion and Justification
Act of Parliament	It can be seen from Table 4.2 that most of the features and elements of the Act of Parliament as a mitigation measure match the three selection criteria.	Because enacting a specific Act of Parliament for Megaprojects has the potential to reduce and mitigate costs associated with legislation changes, it could contribute to reducing the systematic cost overrun in Megaprojects [163]. Further, it reduces the delay in the construction phase that could result from the turbulent regulatory and political environment of Megaprojects [67, 223].	The current study argues that, because the Act of Parliament matches the selection criteria, and it is strongly associated with success indicators, it can be considered as a generic and critical measure for Megaprojects.
Political Risk Insurance	It can be seen from Table 4.2 that only political risk insurance has met just one criterion, which is the ability to manage several non-commercial risks in Megaprojects.	Because the political risk insurance is more sensitive to the geopolitical circumstances [239], it is very expensive and has the potential to reduce the systematic cost overrun in a particular type of Megaproject, such as oil and gas Megaprojects, rather than others [273].	The current study argues that, because the features of political risk insurance do not match the selection criteria, it is very expensive and not generic to Megaprojects.
Bilateral Investment Treaties	It can be seen from Table 4.2 that most of the features of BITs do not match the selection criteria mainly because these measures can only affect Megaprojects in countries that have particular BIT relationships.	Because BITs are more specific measures that have the effect of prohibiting governments from engaging in ex-post opportunistic behaviour such as expropriation [274], they have the potential to reduce the high costs associated with such extreme events [68]. However, BITs are a controversial mitigation measure because they impose limits on political sovereignty and regulatory autonomy [275].	The current study argues that, because the features of BITs do not match the selection criteria despite their effectiveness in reducing cost overrun in Megaprojects, they are neither generic nor critical to the delivery of Megaprojects.
Project Management Office	It can be seen from Table 4.2 that most of the features and elements of the Project Management Office as a mitigation measure match the three selection criteria.	The significant value of the PMO concerns bringing together all stakeholders, building a relationship, understanding people and facilitating proper conversation at the appropriate time [245, 270, 271]. However, although the PMO cannot guarantee there will be no more delays or cost overrun in projects, having a PMO could reduce	The current study argues that, because most of the features of the Project Management Office match the selection criteria, which are also strongly associated with the success of Megaprojects, it can be considered

Mitigation Measures	Matching Selection Criteria	Megaproject Success Indicators	Discussion and Justification
		delays in both planning and construction phases and eventually cost overrun, by applying bespoke methodologies for Megaprojects [272].	as a generic and critical measure to Megaprojects.
Code of Practice	It can be seen from Table 4.2 that most of the features and elements of the code of practice as a mitigation measure match the three selection criteria.	The concept of using codes of practice is an essential measure for all Megaprojects since it can support the delivery team with best practices, processes, procedures and mechanisms to effectively deliver the Megaproject [172, 212]. Thus, having a specific code of practice for Megaprojects could improve Megaproject performance and productivity, hence reducing project delay, especially in the construction phase [276].	The current study argues that, because most of the features of the code of practice match the selection criteria, which are also strongly associated with the success of Megaprojects, it can be considered as a generic and critical measure to Megaprojects.
Dispute Resolution Mechanisms	It can be seen from Table 4.2 that only part of the features and elements of the dispute resolution mechanisms as a mitigation measure match the three selection criteria.	The scale, complexity and diversity of stakeholders in Megaprojects inevitably increase the level of claims and disputes, which consequently leads to significant delays and additional costs to the project [41, 277]. Thus, having dispute resolution methods inevitably helps to reduce any delay that could result from such disputes in both planning and implantation phases; hence helps to reduce the associated costs [278].	The current study argues that, although dispute resolution mechanisms essentially influence the success of Megaprojects, such methods are not generic to all Megaprojects; hence they are not considered as critical mitigation measures.
Investment Agreement	It can be seen from Table 4.2 that only part of the features and elements of the investment agreement as a mitigation measure match the three selection criteria.	Having investment agreements between countries has an impact on the success indicators of Megaprojects, especially in terms of the delay in the construction phase as well as cost overrun. However, and because investment agreements are designed to protect the foreign investment from arbitrary governmental actions, it only impact the delivery of Megaprojects with direct foreign investments such as those under PPPs [279].	The current study argues that, because the features of investment agreements do not match the selection criteria, and they are not applied across all Megaprojects, they are not considered as a critical mitigation measure.

Mitigation Measures	Matching Selection Criteria	Megaproject Success Indicators	Discussion and Justification
New Form of Contract	It can be seen from Table 4.2 that most of the features and elements of the new form of contract as a mitigation measure match the three selection criteria.	Given the scale of all Megaprojects, it is challenging to comprehend these undertakings as a whole; therefore, the tendency is to decompose or factor them into smaller and more manageable packages [197]. Accordingly, developing a new form of contract to manage different types of systems [6], has a direct impact on managing contractual interfaces, which hampers creativity, especially when parties focus on contracts instead of problem-solving [134]. This would eventually reduce the associated delays and cost overrun with the incomplete contract, especially in the construction phase [6].	The current study argues that, because most the features of the new form of contract match the selection criteria, which are also strongly associated with the success of Megaprojects, it can be considered as a generic and critical measure to Megaprojects.
Project Initiation Routemap	It can be seen from Table 4.2 that only part of the features and elements of the project initiation routemap as a mitigation measure match the three selection criteria.	A project initiation routemap as a mitigation measure could help to manage different types of risks, such as the lack of a clear link between the project and the organisation’s key strategic priorities [222]. Thus, it could help mainly to reduce the delays associated with early planning phases.	The current study argues that, although the project initiation routemap has a direct influence on planning delays, it is an advisory mitigation measure; hence it is not critical to Megaprojects.
Special Purpose Vehicles	It can be seen from Table 4.2 that only part of the features and elements of the special purpose vehicles as a mitigation measure match the three selection criteria.	Special purpose vehicles are typically created to control the risk of design, including deficiencies in the design process and final drawings of the project [256].Thus, these measures could directly influence the delay and cost overrun in the construction phase. However, the impact of such measures can only be effective for Megaprojects using such vehicles because they are typically involved in Megaprojects for project partnering and project financing purposes [280].	The current study argues that, although special purpose vehicles essentially influence the success of Megaprojects, such methods are not generic to all Megaprojects; hence they are not considered as critical mitigation measures.

It can be seen from Table 4.3 that it is populated with the outputs of QCA for all recommended mitigation measures for Megaprojects in two aspects: the selection criteria and Megaproject success indicators. The second column of Table 4.3 shows that only four mitigation measures are met the selection criteria namely Act of Parliament (ACT), Project Management Office (PMO), Code of Practice (COP), and New Form of Contract (NFC). Whereas, the third column of Table 4.3 shows that the recommended mitigation measures have a direct/indirect influence on the success indicators of Megaproject success, namely: cost overrun, delayed in the planning phase, and delayed in the construction phase. Interestingly, it is found that only four mitigation measures have a direct influence on Megaproject success; these are Act of Parliament (ACT), Project Management Office (PMO), Code of Practice (COP), and New Form of Contract (NFC). Accordingly, both the Second and Third columns help the researcher to rationales the two decisions in order to select and derive CMMs, as shown in the fourth column of Table 4.3. Thus, these four measures are listed in Table 4.4 and considered as Critical Mitigation Measures for Megaprojects, which are defined and justified with more details in the following sections.

Table 4-4 List of Critical Mitigation Measures for Megaprojects

ID	CMMs
CMM1	Act of Parliament (**ACT**)
CMM2	Project Management Office (**PMO**)
CMM3	Code of Practice (**COP**)
CMM4	New Form of Contract (**NFC**)

4.3 Definition of Megaproject Common Risks

Risk management theory is adopted in the current study to answer the research question, hence achieve the research aim and objectives. Risk identification is the first process in risk management [96, 281]. According to Al-Bahar and Crandall [72], risk identification is defined as the process of systematically and continuously identifying, categorising and assessing the initial significance of risks associated with a construction project. Pioneering research in any field often starts with identifying and defining concepts and developing categories or taxonomies [225]. The current study follows this trend by using a systematic process for identifying a set of five MCRs as listed in Table 4.5. The proposed identification process for the MCRs is outlined, explained, discussed and justified in more detail in Chapter 5 (Sections 5.5.1 – 5.5.4). Each MCR in Table 4.5 is defined and justified thoroughly in the following sections.

Table 4-5 List of Megaproject Common Risks

ID	Name
MCR1	Adaptability to Legislative and Political Changes
MCR2	Aligning Stakeholders' Expectations
MCR3	Scaling-up
MCR4	Operability
MCR5	Incomplete Contract

4.3.1 Adaptability to Legislative and Political Changes (MCR1)

This risk is defined as the Megaprojects' lack of adaptability to unexpected changes in legislation, policies, and regulations by the local or national government during the development process could affect the project's outputs; hence its commercial viability. Given that fact that Megaprojects involve high interdependencies [282], numerous stakeholders [81] and huge investments [63], when unexpected changes to legislation and/or policies occur, the profitability of running a Megaproject can be adversely affected to the extent that the consequences cannot be insured against, or the premiums would be very expensive and unfeasible for the government. The upcoming British Exit (Brexit) from the European Union is a current typical example of unexpected changes in legislation and policies [283]. A recent report from the NAO on the likely impact of Brexit on the Government Megaprojects Portfolio (GMPP) has shown that 10 out of 138 existing Megaprojects will be affected by Brexit based on the IPA assessments [284]. The report also reveals that no new Megaprojects have entered the GMPP as a result of Brexit, as at March 2017 [284]. This emphasises the scale of impact of risks of legislations on the delivery of Megaprojects.

Although there are many causes behind the lack of adaptability to legislative and political changes, such unexpected changes in legislation and policies can be mainly attributed to an unstable political environment or change to the local or national government which, by and large, are beyond the control of project participants [134]. For example, given the long life cycle of a Megaproject, which almost always exceeds the tenure of particular legislators or political parties [239], the delivery performance is more likely to be impacted and influenced by a large number of laws being changed, modified or revisited. Megaprojects are more likely to face unexpected changes in legislation and policies not only because of their lengthy life cycle, but also because they are often owned by governments [155, 160], where policymakers have a tendency to use their power to advance their own interests, or the interests of their financial backers, by changing policies and/or regulations [2, 194]. The unstable environment in which Megaprojects are developed and operated [51, 137] increases the probability of occurrence of legislative changes compared with short-term conventional projects.

Given the multi-ownership of Megaprojects, which can comprise one or more governments (local and/or national) and several major global organisations [285], the project team is not typically in a position to exert any control over the unexpected changes to legalisation and/or policies that would affect their project adversely. In fact, because legalisation and policies often result from the decisions of people, which cannot be measured and anticipated, it is externally hard to measure and anticipate policy changes over the long life cycle of Megaprojects. Therefore, these unexpected changes in legislation and/or policies can trigger sudden changes to initial conditions of project cost estimation [13], which can have a knock-on effect and culminate in cost increases.

Further, Megaprojects, especially infrastructures, have significant impacts on community, environment and economy [63], so they are more sensitive to any change to legalisation and policies compared to conventional projects, such as changes in business tax, urban planning and environmental protection. The scale of Megaprojects means more elements, contracts and interfaces, which in turn make Megaprojects more exposed to unexpected legislative changes than other, conventional projects [51]. For example, tax changes on importing steel can have dramatic effects on the construction of Megaprojects to the extent that the local market and supply chains are not able to meet the demand in the same way as for conventional projects. A recent NAO report has shown that the UK government may have to compensate NNB Generation Company Limited (NNBG), who will build and operate Hinkley Point C (HPC), up to £22 billion (in 2012 prices) if government policy changes in a way that could result in HPC's shutdown [286]. Therefore, if this risk occurs, it could significantly affect the viability of Megaprojects because they involve large investment and financing commitments. In the worst-case scenario, unexpected changes to legislations and policies can create disastrous events such as expropriation and nationalisation [65].

4.3.2 Aligning Stakeholders' Expectations (MCR2)

This risk represents aligning the views, needs and expectations of the key project stakeholders (both internal and external) at different organisational levels (corporate, strategic business unit and operational) to deliver the project with the anticipated outputs and to achieve long-term commercial viability [14, 41, 67]. Stakeholders have been identified as individuals, groups or organisations including both internal and external parties [41]. The internal stakeholders comprise the project owner, financial stakeholders who are looking for financial returns, sponsors (client organisation), management consultant, contractors, subcontractors and suppliers [81]. External stakeholders include community groups, unions, the public, regulatory bodies, the media and special interest groups [81].

All stakeholders may exert influence over a project and its outputs and outcomes. However, external stakeholders are a major source of exogenous turbulence to Megaprojects, which can take the form of public oppositions, land acquisition and project expropriation [287]. These events could negatively affect a Megaproject's outputs because even a small mistake can determine a project's failure or success**.** Therefore, failing to meet the expectations of the project's stakeholders can impact the project's chances of success. Although there are many causes behind the misalignment of stakeholders' expectations, the main ones are the number and diversity of stakeholders, the scale of political and/or public opposition, contractual disputes and multiple-ownership.

Given the fact that Megaprojects involve a significant number of stakeholders with high levels of diversity in terms of culture, discipline and project interest, the misalignment of stakeholders' exceptions is a very common risk [47, 63, 64, 288]. A possible reason for this is that each stakeholder has a different level of involvement in the project, where some of them are more interested than others;

hence aligning stakeholders' expectations is a thorny issue if each stakeholder's interests are to be maintained [63]. Another reason could be attributed to the long life cycle of Megaprojects, where stakeholders may change over time, so new stakeholders can join the project, and existing stakeholders can leave it [41, 158]. Accordingly, stakeholder aspects like power, influence and, attitude towards the project can also change over time and create inconsistency [289].

Megaprojects may become the object of opposition that prevents implementation or damages their long-term success because there is always a tension between different stakeholder interests and agendas [137]. Public opposition can increase with the increase of a Megaproject's impact on the environment, social life and economic situation of the region where the Megaproject is established. For example, a lack of political support from the government can easily derail a Megaproject's schedule because of serious delays due to bureaucratic reasons or judicial processes [290]. Therefore, during the course of negotiations or after a Megaproject is built, affected parties may raise their claims, which may take a very long time because of the scale of the Megaproject and the diversity of the affected parties. As a result, the Megaproject could suffer from excessive delay, which means more financial losses and cost overrun.

Disputes and conflicts between different parties are also a common source of misalignment of stakeholders' exceptions in Megaprojects [35]. This is supported by Ogunlana [291], who argues that it is very common for construction projects to suffer from delays and budget overruns due to disputes among the parties. The multiplicity of stakeholders in a Megaproject means that each stakeholder may have very different views on the success of the Megaproject, which in turn increases the chance of disputes [68]. Contracts awarded on the basis of low costs are particularly vulnerable to disagreements between the contractual parties. Such disagreements can lead to claims, payment delays and disruption to project schedule [35].

Given the complex, multi-ownership nature of Megaprojects, many interface agreements and integration risks exist associated with both construction and operation activities. Megaprojects seldom involve only one sponsor and/or one governance body at the core, but rather coalitions and alliances of various delivering groups. The multiplicity of stakeholders' nature of Megaprojects means that different views on the success (or otherwise) of the endeavour can exist [292] because each party has different interests in the project, where stakeholders/influencers may change over the life cycle of the contract.

4.3.3 Scaling-Up (MCR3)

The Oxford Dictionary defines scaling-up as “the action of increasing in size or number, expansion” [293], whereas scalability is defined as “a characteristic of a system, model or function that describes its capability to cope and perform under an increased or expanding workload” [294]. In the corporate context, a scalable firm is one that is able to maintain or improve profit margins while the volume of sales increases [294]. As a risk, scaling-up can thus be understood in this research as lack of adaptability of Megaprojects to the transition of resources, practices, processes, procedures, means and methods, and systems from conventional-scale (small or large) to Megaprojects scale due to three key dimensions: project scale by any metric, project duration and project complexity.

Although there are many causes behind the scaling-up risks in Megaprojects, the main ones are physical size, cost, scope, complexity, technology, project duration and impact. The research found that these causes are strongly connected to the extent that they can be combined into one major risk, namely Scaling-up. These causes share the fact that the scale of a Megaproject limits the capabilities of the project team to adapt to such a scale when things do not go as desired.

The scale of Megaprojects is a major source of risks in comparison with conventional construction projects. In fact, Megaprojects are more than a scaled-up version of conventional construction projects because they include elements and risks that only exist in the Megaprojects context. Scaling-up best conventional-scale practice, processes and procedures to Mega-scale is often challenging as it can be associated with difficulties during implementation and operation, even with the best intentions [6]. For example, the scale of a Megaproject’s physical assets is one of the main factors that limit the capabilities of contractors to develop such a project, because they may be neither competitive nor technically competent for a project of this scale [248].

In terms of the cost, the scale of financial arrangements is one of the major risks that arise from the scale of Megaprojects [9]. The huge cost of Megaprojects, which is usually defined in billions of pounds, is a significant challenge to finance this sort of project. If a financial risk occurs, it could cause major consequences for many parties in a Megaproject, starting from the government through to the client, supply chain, taxpayers, shareholders and other stakeholders. The Channel Tunnel Rail Link is a typical example of a Megaproject that suffered from financial risks as it was in danger of collapse due to financial difficulties, with resultant uncertainty for Channel Tunnel Rail Link operations and jobs [295].

The scale of complexity of Megaprojects in both technical and organisational aspects is another source of scaling-up since it can lead to frequent design changes [67, 150], which, in turn, increases the challenge to the project team to modify their design smoothly. The Channel Tunnel Rail Link again is a typical example of a Megaproject associated with massive design changes and delays resulting from the escalation of safety, security and environmental requirements demanded by both British and French Governments [23]. Further, Megaprojects very often involve untested and unproven technologies, which often incorporate many uncertainties [92]. These uncertainties are attributed to the difficulties in demonstrating ex-ante the economic effectiveness and efficiency of new technologies [158]. Therefore, scaling-up risk can easily cause projects to be excessively delayed or hindered since it is difficult to anticipate potential challenges and other uncertainties of untested scaled-up major construction activities [296].

The scale of the duration of Megaprojects [64] also limits the capability of the project team to anticipate many changes in many aspects, including social, technical, economic, environmental and political. For example, given the very lengthy time-frames that apply to the development and implementation of Megaprojects [2], it is particularly difficult to keep the identified goals and objectives consistent; hence difficult to anticipate changes to these goals and objectives. Moreover, stakeholder aspects such as power, influence and attitude towards the project, can also change over the long life cycle of Megaprojects [289]. This inconsistency can be argued as a major source of risk that can create contractual disputes among the stakeholders, huge interfaces, excessive delay and cost overrun.

4.3.4 Operability (MCR4)

The term "operable" is defined as "capable of being put into practice" [297], whereas the term "operability" is defined as the ability to keep a piece of equipment, a system or a whole industrial installation in a safe and reliable functioning condition, according to pre-defined operational requirements [298]. It is also defined as "the degree to which the project meets its scope objectives for the quality of the constructed facility and its technical operating capacity, compared with the Industry Average for comparable projects" [299]. The operation risk is defined as the probability that the facility fails to perform its full functionality or its failure to generate adequate units of output or excessive consumption of resources [203]. In this research, the risk of operability refers to the lack of effectiveness of project facilities in performing with the necessary functionalities as designed upon commissioning [134], which can be manifested differently such as failure/delay in operation, excessive maintenance and refurbishment [193], and adverse impact of core services delivery [300]. In contrast, good operability means essentially that a project can be operated easily, i.e. it can cope with unknown disturbances, offsets and other uncertainties with the smallest possible profit loss and without frequent shutdowns.

The above argument underlines that operability is a key concern to Megaproject clients that represents a huge threat to achieving commercial viability [301]. This is because Megaproject viability mainly depends on the ability to generate appropriate returns from operations in order to repay large debts and high-profit investment costs [134]. This argument seems to be in line with a study by Brian *et al.* [302], which demonstrates that the viability of a Megaproject depends quite heavily on the ability of the project to achieve substantial performance improvement over the whole life cycle phases. In fact, Allport and Ward [82] argue that operational risks in infrastructure Megaprojects can be escalated to affect the whole project and sometimes create strategic risks for associated organisations. Then the financial consequences may be great and the impacts upon the organisation's reputation profound.

The lack of operability of Megaprojects can be attributed to many reasons such as design deficiencies, lack of resources, incompetent operator, unforeseen maintenance issues or environmental impact. However, all of these causes are heavily associated with the lack of early engagement of the operator in the appraisal phases. Operational success apparently requires decisions during the preceding planning and implementation stages to be communicated to the operator; it is too late after operations start for by then most revenues, operational costs and broader impacts are substantially committed [137]. Unfortunately, given the scale of Megaprojects, it is very difficult to demonstrate ex-ante the design constructability and efficiency of operations. Studies have shown that operation and maintenance agreements are not always entered into at the time at which the financing of the relevant project is agreed [303]. According to the Infrastructure and Projects Authority (IPA), there is no strategic engagement with senior and experienced operators and/or supply chain from the outset to ensure that the project solution is defined, developed, constructed and handed over appropriately [257]. This could lead to an inadequate focus in defining the end-state, failure to plan systems integration, testing, commissioning handover and snagging at an early enough stage as a key early risk to Megaprojects.

It has been argued by some authors that it is necessary that the project is managed as a whole, and this needs some continuity in thinking, staffing, process and assumptions between the phases [137]. However, given the unfitness and long life cycle of Megaprojects, the discontinuity and lack of accountability is a very common cause of the lack of operability [28]. A likely explanation for this is the nature of Megaprojects, in that very few individuals (even at the very top of the organisation) have a comprehensive view. By definition, a Megaproject will take many years from inception to completion [61], and those who complete it will not be those who were there at the inception. Inevitably, those who are at the end of a project which is delayed or late in delivery will cast blame on poorly constructed planning earlier on, etc. This underlines that the view of the major risks will be skewed, by both the discipline of the person making the judgement and by the stage of the Megaprojects in which they have been involved. Further, the lack of frequency of Megaprojects also has implications in that the operators and other experts may be untrained and unfamiliar with such scale of operation and maintenance. Accordingly, this can limit their skills and capabilities to effectively operate Megaprojects, as happened in relation to the Heathrow

Terminal 5 opening delay (pre-operation training/testing impacted on baggage handling) [82].

Megaprojects often rely on sophisticated and non-standard technological solutions, which often incorporate many uncertainties that could affect their operability [65, 158]. Given the long life cycle of Megaprojects, such technologies tend to change rapidly; hence, these are not thoroughly tested in commercial operation. Therefore, the operator of such a project requires specific training around particular untested technologies. In fact, even proven technologies used on an unprecedented scale such as Megaprojects [63, 282] can bring unforeseen challenges that can significantly increase the risk of operability. Moreover, studies have shown that Megaprojects are very complex in that their operation and maintenance phases often require significant skills that a single-purpose project company may not have, either in its workforce or intellectual property resources [303]. Problems with the application of the proposed technology during operation may result in lower performance, leading to diminished operational cash flows [193]. Further, growing competitive pressure results in the premature use of technological solutions that have not yet been fully developed and tested, potentially jeopardising completion and aggravating operating risks [304].

4.3.5 Incomplete Contract (MCR5)

The definition of an incomplete contract is well documented in the literature; it is defined as a contract that has duties and controls but also has a weakness to anticipate every future incident and contingency [6]. Maskin [305] considers a contract to be “incomplete” if it is not as fully contingent on the “state of the world” (the resolution of uncertainty about the future) as the parties to the contract might like it to be. In another study, the incomplete contract is defined as a contract that is associated with inaccuracy, vagueness, inflexibility, excessive variation, inconsistency, inequitable risk-sharing and unclear division of responsibility [306]. Based on these definitions, the term incomplete contract is defined in this research as contract deficiencies to recognise Megaprojects’ boundaries due to their massive scale, turbulent life cycle, and inherent complexity; hence, it fails to accommodate the necessary provisions, actions and mechanisms to effectivity manage risks in Megaprojects.

Although the incomplete contract is well understood in the context of conventional construction projects, it is quite expensive and often ineffective in Megaprojects to the extent that it might cause conflicts and prevent flexible and adaptive actions from being executed [6]. Further, owing to the huge cost of Megaprojects, an incomplete contract is a major risk that could negatively affect the delivery performance. Incomplete contract means that interactions and influences can be difficult to discern; hence, the intended mitigation measures for such interactions may not occur, and those measures may instead produce unintended consequences [197]. It also means that the overall cost is extremely difficult to discern, unlike in a “fixed-price” contract, which may hide additional cost increases and inflated claims by other parties; hence leading to more financial issues [292].

The huge number and diversity of stakeholders in Megaprojects make it very difficult to discern which stakeholders/participants will influence project outputs [64]. Therefore, an incomplete contract increases the chance of disputes and conflicts, leading to major legal and financial consequences and possible project suspension or termination. For example, in the case of the Rabigh (Saudi Arabia) oil refinery Megaproject, engineering issues and scope changes (the case in an incomplete contract) were identified as major factors that contributed to the project’s cost increasing from US$3 billion to US$9.8 billion [307]. Further, it is another source of disputes because each party can interpret missing information or contract clauses differently based on their own interest. Therefore, parties must have a mechanism to negotiate incomplete contracts in order to shape awareness to accommodate problems that have not yet arisen [308].

The lengthy and turbulent nature of Megaprojects [64], which is characterised as a very long gestation period of many years, is one major source of incomplete contract. The long life cycle means that Megaprojects are associated with unpredictable future conditions and unknown variables which can never be fully predicted or described. These include but are not limited to unexpected changes in policy and regulatory requirements [155], market volatility [63], demand forecasts [309], upcoming technology [65], weather and climate conditions [310], stakeholders’ requirements/agendas [64], impact of/on macro aspects (STEEP) [66], and future best practices [6]. These factors are associated with a lot of uncertainties, which cannot be covered in the conventional contract because it is difficult to foresee all possible contingencies to mitigate them. Consequently, this long gestation period of Megaprojects [86] makes the management of risks an especially challenging task. This necessities more flexible/dynamic contract systems than seen in static/conventional contracts, to provide adaptive controlling measures to effectively manage and mitigate incomplete contracts.

4.4 Definition of Critical Mitigation Measures

4.4.1 ACT (CMM1)

This section provides an overview of the historical establishment of a parliamentary system and its development over time in the UK. It reviews how parliament functions and how legislation, particularly in terms of Acts of Parliament, is provided. The use of Acts in connection with large projects is outlined, ranging from canals to the early railways in the late 1800s, and how an act is enacted is discussed. The significance of the Act of Parliament in Megaprojects is presented and justified. Finally, the recent use of Acts for Megaprojects such as HS2 is then examined.

Historical establishment of the parliamentary system in the UK – The origins of the modern UK Parliament can be traced all the way back to the Anglo-Saxon government, from the 8th to 11th centuries [236]. The first English Parliament was convened in 1215, with the creation and signing of the Magna Carta, which stated the right of the barons (wealthy landowners) to consult with and advise the king in his Royal Council (later known as the Parliament) [311, 312]. The Magna Carta is considered to be one of the most important documents in the world because it established for the first time the principle that everybody, including the king, was subject to the law [311, 313]. In 1327, both knights of the shire and of the town’s burgesses became a permanent part of Parliament. In 1414, Henry V acknowledged that the approval and consultation of both the House of Commons and the House of Lords were necessary to make new laws [236]. Therefore, this decision represents a significant move forward for Parliament by giving it the power needed to make laws. In 1529, the Reformation Parliament passed legislation touching on every aspect of people's lives and made King-in-Parliament the sovereign lawmaker in the realm [236].

In 1707, the Act of Union was passed by both the English and Scottish Parliaments to create the United Kingdom of Great Britain (UK) and Northern Ireland [236, 314]. According to the Act of Union, the UK is represented by one and the same Parliament, which is the Parliament of Great Britain (or Parliament of the UK) [315]. At present, and based on parliamentary sovereignty, the UK Parliament is the supreme legal authority in the UK constitution, which can create or end any law [236], and there is no piece of legislation beyond its reach [316]. Constitutionally, the courts cannot overrule Parliament’s legislation, and no Parliament can pass laws that future Parliaments cannot change [236]. The current UK Parliament is made up of three central elements: the House of Commons, the House of Lords and the Monarchy [236]. Constitutionally, the Monarch, which is the head of state of the UK under a variety of titles – king, queen, prince, or princess [317] – gives the final decision either to approve or reject a law [318]. This clearly underlines that the Monarch (currently Queen Elizabeth II) has significant power in making laws in the UK.

The functioning of the UK Parliament – The UK Parliament [236] defines an Act of Parliament as a Bill (proposed law) that has been approved by both the House of Commons and the House of Lords and been given Royal Assent by the Monarch to create a new law or change an existing law, which is known as Statute Law in the UK. In simple terms, an Act of Parliament provides for the establishment of new laws or changes to existing laws through a legislative process in the UK Parliament. Acts of Parliament are known as “primary legislation” because they are created by the UK Parliament and do not depend on other legislative authorities [319], whereas laws created by ministers (or other bodies) under powers given to them by an Act of Parliament are known as “secondary legislation” [236]. Once new laws have been passed by Parliament, the UK Government is the body responsible for bringing them into force through enforcement agencies such as territorial police forces [236, 283]. Once a new law has come into force, Parliamentary committees are responsible for post-legislative scrutiny to investigate how well an Act is being implemented by the Government and the effect that the new law is having [320, 321].

The process of legislating an Act of Parliament in the UK system starts with a Bill. There are different types of Bills, which can be introduced by the government, individual Member of Parliament or Lords, and private individuals or organisations to either the Commons or the Lords [236, 322]. Most of the draft Bills are examined, discussed and amended either by select committees in the Commons or Lords or by a joint committee of both Houses through a systematic process of five steps – first reading, second reading, committees stage, report stage, and third reading, as shown in Figure 4.2 [236]. When both Houses have agreed on the content of a Bill, it is then presented to the Monarch for approval (known as Royal Assent) [236, 323]. A Bill can start in the Commons or the Lords and must be approved in the same form by both Houses before becoming an Act (law). Once Royal Assent is given by the Monarch, a Bill becomes an Act of Parliament and is a law [236]. This underlines that the preparation of legislation in the UK Parliamentary System is an inherently complicated and lengthy process, subject to external pressures and unforeseeable challenges [324].

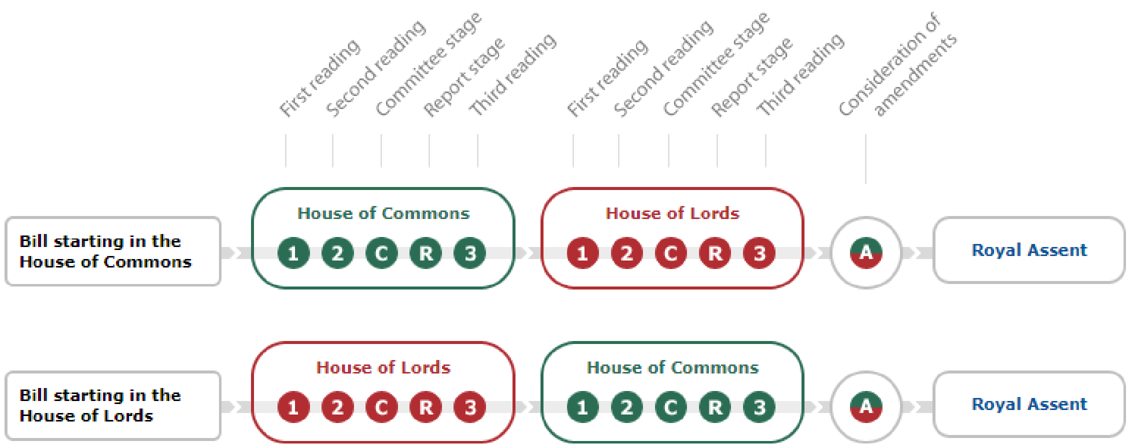

Figure 4-2 Act of Parliament Legislation Process [236]

In order to legislate an Act in the UK system, there are four types of Bills: Public Bills, Private Members' Bills, Private Bills and Hybrid Bills [236]. Among these four types, the Hybrid Bills are the most relevant to authorise Megaprojects in the UK. Examples are the Channel Tunnel Bills passed in the 1970s and 1980s that affected the South East of the UK, and the Crossrail Bill to build a new east to west rail link through central London passed in 2008 [236]. Hybrid Bills are proposed by both public and private bodies because they would affect the general public but would also have a significant impact on specific individuals or groups

[236]. Irrespective of the above types, Bills are drafted for the sake of eventually being enacted. Therefore, to legislate a generic Act of Parliament for all Megaprojects, a Hybrid Bill is probably the most suitable option compared with the other types of Bills. The key rationale behind this suggestion is that most Megaprojects involve a large number stakeholders from both public and private sectors, and this means having different points of views that need to be taken into consideration in the legislations process [41, 158]. Further, a Megaproject's scale of impacts on the public, environment and economy [86, 139] requires input from both public and private sectors in the legalisation process.

Reference to the use of Acts of Parliament for infrastructure development in the UK – The UK Parliament has played a fundamental role in shaping and developing the UK towns and infrastructure since the early 1400s [236]. Parliament's contributions are translated into thousands of pieces of legislation, which have been enacted to develop four broad directions: roads and railways, canals and rivers, town and country, and infrastructure planning.

Roads and Railways – There has been much public legislation governing roads and railways. From early times, transport petitions have been submitted to Parliament about roads [236]. For example, the earliest statute regarding a road was passed by Parliament in 1421, whilst the first Turnpike Act was passed in 1663, allowing the collection of tolls on a section of the Great North Road [236]. These shreds of evidence reflect the early contribution of Parliament in legalising and regulating the infrastructure projects in the UK. In fact, Parliament's role became more critical and recognisable by 1846, when it had to consider more than 700 railway Bills [325]. For example, the Oystermouth Railway, which ran from Swansea to Oystermouth, is considered to be the first public passenger railway and was approved by Parliament in 1804 and opened in 1807 [326]. In 1853-54, Parliament authorised the first underground line in London, to link Paddington with Farringdon [327, 328]. In 1864, the UK Parliament moved forward towards legalising and authorising major projects by appointing for the first time a joint committee to consider underground line proposals [236, 328]. This underlines that most major infrastructure schemes (Megaprojects) require an Act of Parliament, which means that scrutiny is referred to a parliamentary committee [329]. However, in 1992, a simplified authorisation procedure was introduced by Parliament under the Transport and Works Act 1992 [236]. Under this 1992 Act, major schemes such as Megaprojects can be authorised by order of the Minister of State for Transport rather than, as before, on the passing of a private bill [329]. This also reflects the significant role of Parliament in regulating the development of infrastructure Megaprojects in the UK.

Canals and Rivers – Similar to the roads and railways, the building of canals, like other transport infrastructure projects, was considered in or initiated by the UK Parliament [286]. For example, in 1424, Parliament legislated to place the River Lea in the care of a body charged with maintaining its navigation [236]. In 1759, Parliament passed the first canal Act, which enabled the Duke of Bridgwater to construct a canal linking the collieries at Worsley with Leigh and Wigan at Manchester [330]. Others followed, including major trunk canals such as the Trent and Mersey in 1766 [331], the Forth and Clyde in 1768 [332], and the Leeds and Liverpool in 1770 [333]. In addition to the national projects, the UK Parliament has also contributed to the legalisation of UK overseas projects such as the Suez Canal (Shares) Act 1967, which accommodated provision respecting shares in the capital of the Universal Company of the Maritime Canal of Suez, acquired on behalf of the Crown [334]. The above argument underlines that the Act of Parliament was necessary as a statutory instrument to authorise the construction of infrastructure projects in the UK.

Town and Country – Parliament has also had an immensely important influence on the way towns have developed since the 18th century, where more than 600 Acts were passed to sanction local initiatives for improvement and reconstruction [236]. By the 20th century, the UK Parliament had moved towards enacting modern urban planning legislation such as the Housing and Town Planning Act 1909 and 1919 [236]. The 1909 Act obliged local authorities to tackle substandard housing; new housing developments were encouraged on 'garden city' principles; and 'back-to-back' housing was made illegal [236]. The 1919 version of the Act authorised the local authority to lay out and construct public streets or roads and open spaces on the land [335]. These Housing and Town Planning Acts were modified over the years and replaced by several versions in 1925, 1932, 1944, 1947 and 1954 [236] to establish procedures to control and plan the growth of towns and cities in the UK. These enactments were consolidated into the Town and Country Planning Act 1990 [336], which is currently under further revisions [236]. The above enactments emphasise the early role of Parliament in legalising the development of infrastructure utilities in the UK.

Infrastructure Planning – In terms of infrastructure planning, the UK Parliament enacted the New Towns Act 1946, which allowed the government to designate areas as new towns and pass development control functions to a Development Corporation [337]. This Act was replaced by the New Towns Act 1965 and, later, the New Towns Act 1981. In 2008, the UK Parliament enacted the Planning Act 2008 to speed up the process for approving National Significant Infrastructure Projects (NSIPs) such as transport Megaprojects, power and energy Megaprojects, and waste treatment Megaprojects [338]. In 2011, the UK government introduced the Localism Act 2011, which made some changes to the regime under the Planning Act 2008 [339]. The Localism Act 2011 has replaced the Infrastructure Planning Commission (IPC) with a Major Infrastructure Planning Unit of the Planning Inspectorate, and returned decision-making to the Secretary of State [340, 341]. In addition to these Acts, the UK Parliament has legislated several Acts to legalise the infrastructure development in the UK, such as the Telecommunications Infrastructure (Relief from Non-Domestic Rates) Act 2018, Infrastructure Act 2015, Growth and Infrastructure Act 2013, and Infrastructure (Financial Assistance) Act 2012 [236]. It can be clearly seen that infrastructure planning Acts are generic – they can be applied across more than one project – compared with those that are enacted for a single project.

The significance of the Act of Parliament in Megaprojects – Legislating Acts and other statutory instruments help governments to organise society and protect citizens by determining amongst others the rights and responsibilities of individuals and authorities to whom the legislation applies. This is confirmed by Payne [342], who argued that the source of the government's powers and capacity might be spread across a number of statutes and statutory instruments such as Acts of Parliament. For the current research purposes, Acts of Parliament are defined as statutory measures, instruments, arrangements, controls and guarantees that could potentially accommodate provisions to provide protection against non-commercial risks such as unexpected changes in legalisation and policies, and allowing compensation to cover the associated costs [213, 216, 218]. Owing to the ownership of Megaprojects, which are often launched by governments [285], statutory instruments are fundamental for authorising, planning, managing, delivering and operating this sort of project. In the UK system, Megaprojects are defined by HM Treasury as innovative or contentious, those which require primary legislation, and spending over and above departmental expenditure limits [343, 344].

The literature shows that countries such as the UAE, France, Poland and Mexico have enacted statutory instruments such as PPP laws and regulations [342] to establish a clear institutional framework for developing, procuring, reviewing and implementing Megaprojects under PPP schemes [234]. Institutional frameworks are defined as long-term and stabilising mechanisms of social interaction that provide much of the groundwork for temporary systems [345] such as Megaprojects [43]. This is supported by Miller and Hobbs [189], who argued that the anchoring of projects to institutional frameworks is one of the most critical aspects of Megaprojects. For example, in the UAE, the Dubai Government legislated a law called Law No. 22 of 2015 on Public-Private Partnerships, which enables partnerships that release benefits of private sector management systems, efficiencies and methodologies into the provision of public services, with specific benefits related to the cost, value and quality of services provided [213]. This law provides a set of government guarantees that can be manifested in different forms such as amending the partnership contract in case of unforeseen circumstances, committing to giving the necessary licences, permits and approvals according to the agreed timeframes, and basics and mechanisms for fair compensation in case the conditions of the contract are amended [213]. This underlines that projects embedded in strong institutional frameworks are much better able to withstand and survive the impacts of emergent uncertainty.

The massive impact of Megaprojects on the economy, civil society and the natural environment [63] also necessitates statutory instruments to enable governments (local/national) to monitor and track the outputs and outcomes of these projects. Therefore, countries such as the UK and Australia have legislation which is intended to facilitate the delivery of nationally significant infrastructure projects by centralising and streamlining planning approval and land use processes [346]. For example, in the UK, the Planning Act 2008 is one of the most important pieces of legislation in recent years affecting major infrastructure projects; introducing a radical new regime aimed at speeding up the planning and in turn delivery of projects of national significance in the fields of transport, energy, water, waste and wastewater [347]. Similarly, Greenland has enacted the Large-Scale Projects Act 2013, which aims to promote investments in and performance of large-scale projects of particular importance for Greenland's economic development, whilst taking into account the interests of the population [348]. This Act aims to prevent and restrict unintended negative impacts in terms of macroeconomics and the competitiveness of the business community, including disproportionate increases in general levels of wages and costs as a result of activities within the scope of the Act [348].

Other countries like Panama have specific legislation to stabilise the delivery environment of Megaprojects, which is characterised as very long, highly dynamic and nonlinear [80, 349]. The government of Panama enacted the Investment Stability Law (Law No. 54 of July 22, 1998), which guarantees that foreign investors who invest at least two million dollars in Panama will receive equal treatment under the law to their domestic competition in addition to their taxation and customs conditions for 10 years [218, 350]. This is an important guarantee to ensure that no changes will affect the amortisation of investments. Up to date, more than US$2.5 billion has been registered under the protection of this legislation, ranging from energy and petroleum to industrial and tourism development projects [223]. Due to the turbulent nature of Megaprojects [67], having statutory instruments could enhance the stability of their regulatory and political environment [223]. Further, it could also overcome the complications that may be encountered when there are a number of pieces of legislation that apply to this sort of project. The above arguments underline the critical role of statutory instruments in planning and delivering Megaprojects.

The recent use of Acts for Megaprojects (HS2 Act 2017) – Countries such as the UK and Australia tend to legislate project-specific Acts to authorise the development of a single Megaproject such as the Channel Tunnel Rail Link Act 1996 [351] and Crossrail Act 2008 [352]. The High Speed Rail (London – West Midlands) Act 2017 is the recent example of such an Act, and was enacted to authorise the construction of the first phase of a high-speed railway between

London and Birmingham (High Speed 2) [353]. This Act sets out the approvals required to be obtained by the delivery entity from the relevant planning authority to plan and develop Phase 1 of HS2 [354]. According to this Act, planning authorities should not exercise their regulatory power to extend or alter the scope of the project and/or revisit matters settled through the parliamentary process [354]. The HS2 Act also states that planning authorities should not modify or replicate controls already in place, either specific to the first phase of HS2, such as the Minimum Environmental Requirements, or existing legislation, such as the Control of Pollution Act or the regulatory requirements that apply to railways [354]. Although these provisions may provide some protection against some legislation changes, they are provided for specific conditions of a particular, single Megaproject. Further, these provisions do not provide mechanisms to compensate for the delivery entity in the case of legislation changes. This underlines that the existing statutory instruments have weaknesses in managing risks associated with legislation changes, which commonly influence variations in costs and time in all Megaprojects [355]. These weaknesses justify the need for a specific Act of Parliament to overcome the limitations in the existing legislation system.

4.4.2 PMO (CMM2)

This section aims to provide a critical discussion of the proposed PMO in the UK context by analysing, discussing and clarifying its key aspects including responsibilities, rights, operational challenges, regulatory power barriers, sponsoring and reporting arrangements, and integration challenges with the existing UK institutes and statutory authorities.

What is a national governance system, and why is it important – The Association for Project Management [132] defined a governance system as a set of policies, regulations, functions, processes, procedures and responsibilities that define the establishment, management and control of projects, programmes and portfolios. Biesenthal and Wilden [356] argued that project governance is primarily concerned with aligning project objectives with an overarching organisational strategy, which is necessary to create stakeholder benefits across different organisational levels. Gil and Lundrigan [357] argued that the role of any governance system is primarily to exercise oversight and control over key choices that invariably face the project executive team over time. It is obvious that the above definitions are provided to define a governance system at the project level rather than a national level. Chen and Zhang [358] defined a national governance system as a logical and interlocking system that promotes all constructions in a coordinated manner, and every construction cooperates with each other that can holistic system function fully play and can affect of modernising the national governance system and capabilities be fully achieved. Given the scale of Megaprojects in the UK (£442 billion) [359], having a national governance system to oversee the delivery performance of such projects is crucial. Further, Megaprojects are very complex and complicated undertakings, where the large numbers of stakeholders and institutions involved make the governance of such projects very challenging [189, 360, 361].

The development of the UK national governance system – The leadership and governance system for Megaprojects in the UK is very complex, with organisations with many interfaces among them. It starts with the Office of Government Commerce (OGC), which was established in 2000 as part of HM Treasury to produce a great deal of guidance about best practice in procurement and project management through the Major Projects Directorate (MPD) [283]. In 2005, the Public Sector Construction Clients Forum (PSCCF) was established to strengthen the leadership and coordination of public sector construction activity in the UK [362]. In 2007, the Major Project Review Group (MPRG) was established to improve the performance of major projects and to advise HMT ministers whether projects should proceed [363]. In 2008, the PSCCF was renamed the Construction Clients Board (CCB) as a governing board within the Cabinet Office, chaired by the Chief Construction Advisor (CCA), which was established in the same year to oversee the implementation of government construction procurement and to develop best-value procurement practices [364].The PSCCF aimed to bring stakeholders together to drive further improvements in whole-life value for money in public-sector procurement and comprised all the major public sector procurers, including the regional development agencies. In 2010, Infrastructure UK (IUK) was created as an important step towards taking a long-term strategic view of infrastructure priorities and to secure private sector infrastructure investment [365]. The Efficiency and

Reform Group (ERG) was also created in 2010, which has a role in assessing the impact of major projects, which considers that it is primarily for departments to assess and manage any impact of its other activities on service delivery [366].

In 2010, the MPD was absorbed into the ERG, and after one year it was replaced by the Major Projects Authority (MPA). The MPA was established and given a mandate in 2011 to oversee 200 of the largest government projects totalling nearly £500bn in public spending. The MPA aimed to bring about the successful delivery of major projects across central government by working with departments to ensure the fitness and quality of Major Projects throughout their life [343]. In 2011, the CCA was reconstituted with additional representative members to become the Government Construction Board (GCB) to oversee the implementation of Government Construction Strategy 2011-2015, and reports to the Minister for the Cabinet Office [364]. This strategy was the first of its kind, which was collaboratively prepared by the ERG, Construction Sector Unit of the Department for Business Innovation and Skills (BIS), and the IUK [367]. The ERG brings together expertise from different parts of the Cabinet Office, HM Treasury, Directgov, OGC and Buying Solutions [368]. Within the ERG, the MPRG is in charge of reviewing procurement projects across the public sector that are particularly complex and high value-added and assessing their viability [368]. In 2016, the operations of both the IUK and the MPA were combined into one organisation called the Infrastructure and Projects Authority (IPA) to share their in-house knowledge of managing major infrastructure projects [211]. Later in 2016, the IPA and the Cabinet Office collaboratively published the second Government Construction Strategy, Government Construction Strategy 2016-2020 [369]. The IPA is also responsible for monitoring the delivery progress of Infrastructure Megaprojects against the National Infrastructure Delivery Plan (NIDP) [370].

The above outline underlines that the existing leadership and governance system for Megaprojects in the UK is very complex with lots of interfaces among governmental authorities. It also indicates that the IPA is currently the responsible body to oversee and govern the delivery of infrastructure Megaprojects in the UK alongside other major government programmes [370].

What is a PMO, and what are its main functions? – The Project Management Institute [131] defined a PMO as a management structure that standardises the project-related governance processes and facilitates the sharing of resources, methodologies, tools and techniques. Similarly, the Association for Project Management [371] defined a PMO as a group or department within a business, agency or enterprise that defines and maintains standards for project management within the organisation. Greiman [41] defined a PMO as the body that is responsible for setting up bespoke policies, processes, procedures, practices and standards for the projects in the organisation, checking the delivery performance of Megaprojects against these requirements, and reviewing and consolidating reports for external stakeholders. In contrast, Bredillet *et al.* [372] defined the PMO as an organisational innovation initiated to assist project-based organisations better manage and coordinate portfolios of projects. The above definitions underline that the concept of the PMO has an integral part in the governance structure of Megaprojects that can support the executives at a strategic level [373, 374]. The PMO functions can be classified into five broad groups: monitoring and control of project performance, development of skills and methodologies in project management, managing multiple projects, strategic management, and organisational learning [224, 375, 376].

Authors like Hobbs and Aubry [375] have argued that monitoring and control of projects performance are among the key functions of a PMO. The other major task of the PMO is the development of skills and methodologies in project management that are specifically designed for Megaprojects [377]. The PMO will also be responsible for developing the skills, capabilities and competencies within the organisation to help it deliver and support its Megaprojects and help in problematic situations [245, 271, 378]. This requires an effective engagement with the delivery organisations of Megaprojects to identify, define, evaluate and rank best practices, processes and procedures that promote the better delivery of all Megaprojects and only Megaprojects [378]. Therefore, it is recommended that the PMO should also seek international alliances to utilise the global best practices by establishing several agreements with international project management institutes and experts [211]. However, it is obvious that there will be different adherence and compliance to best practices by Megaproject delivery organisations. These differences are probably due to the variation between different organisations' levels of maturity [379].

A number of authors have argued that one of the main functions of a PMO is to align the projects to the organisation's common needs and to meet the expectations of different stakeholders [224, 245, 376, 378]. Given the fact that Megaprojects involve a significant number of stakeholders with high levels of diversity in terms of culture, discipline and project interest, the misalignment of stakeholders' exceptions is a very common risk [47, 63, 64, 288], which can possibly be mitigated through the PMO. Countries like Paraguay have established PMO at the national level to align different stakeholders' expectations. For example, the Paraguay Project Management Office (PPMO) is an example of a PMO at the national level, which has resulted from the country's need to professionalise its project execution through the development of a new management model and to strengthen its institutional capacity in the mid-term [224]. According to a recent report by the World Economic Forum [224], the PPMO is currently responsible for: gathering needs from different public sector agencies/organisations at national, state or district level, aligning common needs, setting the right conditions for project implementation (e.g. propose new regulations) and coordinating inter-ministerial project documentation workflow, creating and prioritising the project pipeline, conducting pre-feasibility studies, preparing request-for-proposal (RFP) documents, and controlling project execution [224].

Managing multiple Megaprojects is another major function of the PMO under its domain [131, 270, 372, 376]. This implies coordination between Megaprojects in order to control and prioritise them and to ensure the proper allocation of resources among them [244]. Among the other fundamental functions of the PMO is providing and maintaining a strategic oversight to senior management to ensure Megaprojects are delivered efficiently and effectively, and to improve performance over time [247, 373]. Some authors have argued that the roles and functions of the PMO are defined in accordance with the strategic objectives of the organisation, and, in general, have to meet the expectations of the senior management and project managers [380].

Different types of PMO – The diversity of the PMO functions underlines that the nature of the PMO could be highly divergent across organisations [377]. According to the Project Management Institute [131], the types of PMO can be classified into three groups: supportive, controlling and directive. Supportive PMOs provide a consultative role to projects by supplying templates, best practices, training, access to information, and lessons learned from other projects. Controlling PMOs provide support and require compliance through various means such as the adoption of project management frameworks or methodologies; use of specific templates, forms and tools; and conformance to governance frameworks. Directive PMOs take control of the projects by directly managing them. Project managers are assigned by and report to the PMO. Although the operations and functions of the above types are different, the PMO can combine various functions with satisfying organisations' different needs [377, 380]. This is supported by Unger *et al.* [270], who reduced and integrated the vast number of PMO functions into a comprehensive set at a multi-project management level.

Strengths and weaknesses of the PMO – The PMO has a number of strengths. At the project level, the PMO can provide oversight on project delivery and incorporate best practices and procedures, which can reduce risks and uncertainty associated with project deliverables and objectives for cost, schedule and resource utilisation [372]. The PMO can also offer control processes by providing consistent, common, repeatable and comprehensive project management methodologies that can be implemented across departments and projects [381]. Therefore, the PMO can provide proven and chosen methodologies by revising them to be simpler and adapted to different realities [377]. Accordingly, the PMO can also offer a consistent and effective framework for collating, summarising and reporting on the progress and status of projects and programmes from multiple sources [247]. The supportive role of the PMO can establish intellectual capability and capacity to support and govern a multi-project environment [271, 376]. By integrating a comprehensive project management capability, the PMO can also play a fundamental role to achieve business objectives [381]. At the strategic level, the role of the PMO as a centre of excellence can provide continuous improvement and cross-department collaboration to achieve strategic business goals [270].

Although the PMO has the above strengths, it also has some weaknesses. For example, due to the diversity of PMO functions, there is a lack of clarity about its mandate, services, roles, scopes and activities among top management to fulfil the needs of the organisation [382]. Such role ambiguity could adversely influence the communication, knowledge management, and creativity and functionality of a project team [378]. Accordingly, there is a lack of consensus on the value of a PMO [243, 377]. This mainly reflects the fact that project managers do not recognise the mission of the PMO and underestimate the PMO’s value to the extent of seeing it as a point of control, which hinders their activities [271]. However, project performance is often used as a key performance indicator to measure the performance of PMOs [383]. Hence, the complexity of Megaprojects may present further challenges to measure the value of PMOs. Another limitation is the unwillingness of project managers to use the PMO’s services proactively by arguing that it is too bureaucratic and might slow down the progress and executes too much control and so reduces flexibility [271, 382]. The other practical challenge with using a PMO involves improving staff capability and capacity capability to support their projects and help in problematic situations. Factors such as the lack of training of new members and junior engineers [163], the turnover in staff and leadership position [188], and the lack of professionals and experts involved in the delivery of Megaprojects [163] make it difficult to keep the team up to date. The establishment cost of a PMO is another issue that has a negative impact on the organisation [384], especially if the expenditures exceed the revenues for a certain period of time. In fact, demonstrating how the PMO’s operations are funded is another practical challenge that project managers face [373]. Van der Linde and Steyn [384] argued that the cost of the PMO is allocated to individual projects so that it can be capitalised.

The application of national PMOs outside the UK – In real practice, there are several examples of the implementation of PMOs at the national level for Megaprojects. The National Project Management, Operation and Maintenance Organisation in the Kingdom of Saudi Arabia (KSA) is an example of a PMO at the national level, which is known as “Mashroat” [385, 386]. Mashroat aims to lead a transformation process to enable Public Entities' Projects and Facility Management Organisations and create a dynamic ecosystem to manage Megaprojects and facilities at the highest levels of efficiency and effectiveness [386]. The key functions of Mashroat can be summarised into two streams [211]. The first stream is enabling project management practitioners by project management methodology and models, project management education and training, and project management research through several functions. The second stream is enhancing project management practices.

Qatar has established its own PMO model, which is called Qatar National Project Management (QNPM) [387]. QNPM is a national initiative that was created in 2005 in the Planning Council to help build and support project professional management capacity in Qatar's public service. It combines international best practice with the insights of local experts who have years of project management experience. It is an evolving initiative that currently includes a framework for managing projects based on a project life cycle, with templates, job aids and other resources, and a software tool to help the user automate project management tasks and work with the team online. It offers practical advice and support for new project leads, experienced project managers and executives interested in how a standard approach to project management can support their organisation's success [388].

The National Project Management Office (NPMO) is another example, this time from the Philippines [211]. The primary function of this NPMO is supporting the mandate of the Bus Rapid Transit (BRT) National Steering Committee and overseeing the implementation of all BRT plans, policies, standards, regulations and projects nationwide [389]. The Major Projects Facilitation Agency (MPFA) in Australia is another example, which aims to provide assistance with government approval processes and to identify existing government assistance programmes for proponents of strategically significant major projects [390]. The MPFA also aims to coordinate Australian and state and territory government processes so that, where feasible, they occur simultaneously and without duplication [390]. The above practical and theoretical examples of PMOs underline that this concept can form a strong framework of Megaproject governance by providing strategic oversight to the delivery of Megaprojects at the national level.

The significance of the PMO in Megaprojects – Megaprojects are large-scale sociotechnical undertakings that are complex and embedded in institutional frames [187]. The need to set up a PMO to institutionalise Megaprojects is supported by many authors like Brunet [391], who conducted qualitative research based on a multiple-case study to advance the conceptualisation for governance as a practice by presenting an institutional project governance framework for major public infrastructure projects. Further, Canada has established its own institutional framework organisation called the Major Projects Management Office (MPMO), which is a governmental organisation that provides overarching project management and accountability for major resource projects in the federal regulatory review process and to facilitate improvements to the regulatory system for such projects [392]. This MPMO is an interesting model of best-practice permit processes, which is Canada’s “one project, one review” approach for resource projects such as pipelines. In 2007, the MPMO was instituted as the central authority for reviewing and monitoring major projects in Canada. As a result, the average approval time for large energy projects was reduced from four years to 22 months between 2007 and 2011 [223].

A number of authors have argued that complex systems such as Megaprojects are characterised by a multicultural governance structure [41, 187]. Therefore, developing and maintaining Megaprojects requires untraditional approaches of decision-making and oversight supported with a wide range of capabilities, including alliance, governance, innovation and learning [41, 138]. This argument is supported by a considerable amount of literature which has been published on the significant role of the PMO in Megaproject governance. For example, Tsaturyan and Müller [271] addressed the governance of PMOs as the integration of loosely-coupled multiple governance units in large project-based organisations. According to the authors, the proposed PMO governance model can help the organisation to be more focused on the long-term strategic goals, which delivers more value to both shareholders and stakeholders, rather than following the daily operational objectives. Martinez Sanz and Ortiz-Marcos [393] explored the similarities between PMO governance and knowledge governance in multi-PMO settings by analysing a case study of large complex IT projects. Brunet [394] contributed to the understanding of the governance of major public infrastructure projects with process and practice-based theories. The above literature shows the fundamental role of PMO governance structures in influencing a set of elements in risk management in Megaprojects.

4.4.3 COP (CMM3)

A code of practice is defined in the Oxford Dictionary as a set of standards that members of a particular profession agree to follow in their work, a recommended code of practice issued to all local government employees [293]. According to the Association for Project Management [395], all leading professional bodies, such as the APM, have a code of conduct to set standards so as to guide professionals and raise the public's level of trust and confidence in the profession. The Infrastructure and Projects Authority [396] used the term "Code of Conduct" to refer to a statement of principles that the review team will adopt to ensure a consistent professional approach in delivering a successful review. In contrast, the British Standards Institution [397] used the term "standard" as an agreed way of doing something, and this could be about making a product, managing a process, delivering a service or supplying materials. Standards can cover a huge range of activities undertaken by organisations and used by their customers [397]. Based on the definitions above and for the purpose of the current study, the term "code of practice" (COP) refers to written a document issued by an official body or a professional association that complements sets of recommended standards and best practices to shape a consistent approach to benchmarking across Megaprojects. The COP is a mandatory document rather than an advisory document, which is expected to be used by practitioners to guide them how to plan, manage and deliver Megaprojects in a better way.

There is a growing body of literature that recognises the importance of codifying, standardising and benchmarking best practices in Megaprojects. Very recently, the IPA has developed a new approach to benchmarking across major infrastructure projects and programmes through the project life cycle [398]. According to the IPA, having consistent, effective benchmarking should help underpin government and industry decisions on project selection and delivery [398]. Wang *et al.* [80] argued that the government could standardise the methods, processes and thresholds of infrastructure decision-making to improve the rationality and standardisation of project decisions, avoiding decision-making errors caused by excessive political domination. Smith [399] argued that the lack of standardisation of management structures and project management styles makes it hard to draw general conclusions. In the Terminal 5 (T5) Megaproject, a single one-size-fits-all approach mandated by the client organisation established a consistent and standardised process and a common code of behaviour which was used uniformly on all sub-projects [400]. This code helps to understand how complex Megaprojects can be successfully managed.

The other key rationale behind the significance of codifying best practices is the lack of high-quality data in Megaprojects resulting from factors such as uniqueness, the incompleteness of design, scoping and contract, and lengthy and extended development processes [2, 37, 65, 69]. In fact, there is no single standard framework to collect data across Megaprojects, which makes records difficult to compare [401]. Authors have argued that the process of gaining the data on best practices based on comparing different Megaprojects against each other to make these sort of benchmarking comparisons is fundamental to the quality of the monitoring of the delivery performance of Megaprojects [292]. According to Blanc-Brude [402], the standardisation of infrastructure investment data collection will allow the emergence of an industry-wide reporting standard. Locatelli [21] concluded that standardisation is one of the recommended aspects that need to be considered for the success of Megaprojects, in particular, for the nuclear sector. Therefore, codifying, standardising and benchmarking data can be of real value, which can be shared and tried out in various Megaprojects with minimal modifications.

Another rationale behind the importance of a COP is the lack of expertise and limited knowledge of individuals involved in Megaprojects [108, 142]. The scale and multi-disciplinary nature of Megaprojects [69] require extensive resources and expertise, which normally exceed the scope, capacity and capability of a single organisation [214]. For example, the diversity of Megaproject types and locations limits the capabilities of construction companies because they may be neither competitive nor technically competent for projects of a similar scale [248]. This justifies the need for a specific code of practice to be developed and used by practitioners with multi-disciplines in Megaprojects to expand their knowledge and understanding in planning and delivering this sort of project; which will hence enable them to understand the risks in Megaprojects. This underlines that codes and standards are fundamental for Megaproject success since they allow practitioners to expand their knowledge base by use of such documents.

As far as can be ascertained, there is no specific COP for managing and delivering all Megaprojects in the UK; instead, the majority of Megaprojects are using the existing codes of practice that can be applied for all projects irrespective of their size and type. For example, Crossrail complies with the Joint Code of Practice for tunnelling projects which is applied to tunnelling projects that cost more than £1 million [403]. This underlines that this code could be applied to a wide range of tunnelling projects based on a £1 million threshold, starting from small-scale tunnelling projects to Mega-tunnelling projects like Crossrail and the Channel Tunnel. However, this concept of one size fits all is not applicable to Megaprojects simply because these are not a scaled-up version of conventional projects [61]. Instead, Megaprojects are completely different from conventional projects; hence, they are associated with unique risks that do not exist in other types of project [41]. The other rationale is the existing codes of practices tend to rely on best practices or good industry practices, which may be applicable only in certain circumstances [6]. While this argument can be true for conventional projects, it does not apply to Megaprojects because the environment in which Megaprojects operate is evolutional, complex and turbulent; hence the existing codes of practice are not well suited to such conditions [62].

The literature review also reveals that, instead of developing a comprehensive and specific COP for all Megaprojects in the UK context, each Megaproject tends to establish its own COP. For example, HS2 Ltd has developed a specific code of construction practice for phase 1 (London – West Midlands) of High Speed Two (HS2) [404]. This code sets out a series of proposed measures and standards of work, which shall be applied by the nominated undertaker and its contractors throughout the construction period [404]. Further, HS2 has drafted another code of construction practice for phase 2 (phase 2b) (Crewe to Manchester and West Midlands to Leeds) of HS2 [405]. Similarly, Crossrail Ltd has developed a specific code of construction practice for Crossrail to ensure that the relevant provisions of this Code are observed by bodies exercising its functions, including any of its contractors and sub-contractors [406]. Thames

Water Utilities Ltd also has its own code of construction practice for the Thames Tideway Tunnel project [407]. This code sets out a series of measures to be applied throughout construction to mitigate the potential impact of site activities [407].

Although the applications of the above existing codes of practices need to be tailored to each specific project, the uncertain and turbulent nature across all Megaprojects requires a UK COP that is specific to all Megaprojects and only Megaprojects, similar to other countries such as Australia. For example, the Australian government through the Australian Building and Construction Commission has developed the National Code of Practice for the Construction Industry to sets minimum standards that businesses must meet to be eligible for certain Australian government building and construction work [408].

4.4.4 NFC (CMM4)

The contract is an important component in realising the objectives of all Megaprojects and plays a key role in the success of the delivery of these projects for many reasons. The huge scale of Megaprojects necessitates breaking them down into a number of manageable packages and outsourcing these work packages to a number of contractors instead of as one package [49]. However, this packaging process has implications for generating a lot of interfaces and holes in these contracts [134]. These contractual interfaces can hinder creativity, especially when project parties focus on their own contracts instead of problem-solving for the whole project [214].

Given the financial scale and resources required for the delivery of Megaprojects [137], contracts can play a fundamental role in allocating risk between project parties [2]. Further, Megaprojects are promoted and delivered within a constantly evolving delivery environment [24], which is quite challenging to reflect best practices in conventional contract systems. Megaprojects are subjected to continuous changes in several aspects [2], including social, technical, economic, environmental and political, requiring a more flexible contract to adapt to such turbulence [51].

Because Megaprojects involve a significant number of stakeholders with different levels of influence and interest in the project outputs [222], the lack of an appropriate contract can lead to a misunderstanding of liabilities between these stakeholders and other parties [103]. Therefore, the complex nature of Megaprojects together with their risks require detailed and carefully written contracts that define (as precisely as possible) the legal, financial and technical aspects of the results and behaviour desired by the contracting parties [2].

Recently, a considerable amount of literature has grown up around the role of the contract in the Megaprojects context. For example, Wu *et al.* [254] through their study provided a better understanding of the relationship between contractual flexibility, types of conflicts in Megaprojects and a reliable reference for the project manager to effectively deal with these related issues. von Branconi and Loch [255] investigated the contracting system for major projects by proposing eight key levers of the business deal encompassed by the project contract. These key levers represent the key issues upon which top management should focus in shaping the contract for major projects.

Smith and Jobling [6] critiqued the existing contractual systems in Megaprojects by showing that scaling-up contracts and procedures in an attempt to offer Megaprojects levels of certainty similar to those of traditional projects does not work. Smith and Jobling [6] provided an alternative view of the contractual context in which Megaprojects are to be delivered by relaxing the specifications for project control tools, which, in turn could encourage the use of more flexible and more appropriate approaches.

Davies *et al.* [186] suggested five rules to manage the uncertainties to all Megaprojects based on more than 10 years of research into Megaprojects. Among these five rules is using flexible contractual arrangements as needed in Megaprojects besides fixed contractual arrangements, which was applied in the London 2012 Olympics and Crossrail Megaprojects [186]. Cruz and Marques [237] proposed a double-entry matrix as a new model for contract flexibility to cope with uncertainty in PPP projects. Bloomfield *et al.* [409] presented a novel approach to the characterisation of ‘systemic risk’ in the context of major public sector procurement and contracting systems.

The above studies underline that having an appropriate contract form for Megaprojects is critical to the delivery performance. This is confirmed by Smith and Jobling [6], who recommended that the role of contracts is something that should be investigated further in attempting to improve the delivery of Megaprojects.

4.5 Synthesis of Theoretical Constructs of the Proposed Approach

The current section aims to present and discuss the synthesis of theoretical constructs of the proposed approach of risk management in Megaprojects. The theoretical concepts that underpin both MCRs and CMMs (presented in Section 4.3 and 4.4 respectively) are synthesised and compared in order to highlight possible theoretical linkages for the development of a proposed approach of risk management in Megaprojects.

The literature review shows that the identified MCRs in Section 4.3 represent a significant threat to Megaproject success because they have negative and systematic effects on the delivery performance of all Megaprojects in terms of cost and schedule. The literature also shows that these MCRs tend to be identified, analysed, treated and mitigated separately and individually [43, 138]. However, owing to the interdependency of Megaprojects [410], even when one of those MCRs occurs individually, it tends to trigger other MCRs with a cascade of problematic effects [411]. For example, the scale of complexity of Megaprojects, both technical and organisational, can trigger the risk of scaling-up (MCR3), which in turn can lead to frequent design changes [67, 150]. As a result, the frequent design changes can strongly trigger the risk of incomplete contract (MCR5). Although MCRs have different sources and different managerial implications, the current study puts forward a possibility to combine, assess and manage MCRs collectively rather than individually as a more significant approach to improve the delivery of Megaprojects. Therefore, there is a need to map up all the identified MCRs inherent in Megaprojects to ensure that a comprehensive approach is developed to manage and mitigate them collectively [412].

The literature also shows that all the identified CMMs in Section 4.2 and defined in Section 4.4 are fundamental elements to the delivery performance of

Megaprojects. The rationale behind this argument is that the elements of CMMs are strongly associated with the features of Megaprojects such as the scale of investment, scale of impact, long development process, high complexity, etc. However, it can be seen from the literature that these CMMs also tend to be applied separately across Megaprojects. Further, there is a dearth of studies that have investigated the integration of CMMs collectively. Therefore, the current study argues that it probably may be logical and practical to integrate and combine the identified CMMs collectively into one package. Although CMMs are completely different, they share common elements, which are necessary to reduce the probability and impact of MCRs, causing the systematic poor delivery performance of Megaprojects. For example, three CMMs (ACT, PMO and NFC) have the potential to manage and mitigate elements associated with aligning stakeholders' expectations (MCR2). The ACT can stabilise the delivery environments of Megaprojects and protect the rights of different stakeholders [218, 350]. The PMO's role as a facilitator is also is fundamental to align different stakeholders' expectations [224, 245, 376, 378]. Further, having appropriate NFC can manage and mitigate the misunderstanding of liabilities between these stakeholders and other parties [103].

Having discussed the theoretical concepts that underpin both MCRs and CMMs to improve the delivery performance of Megaprojects, this fundamental principle can be considered as a theoretical link between them. Therefore, both MCRs and CMMs represent the theoretical constructs to conceptualise a new approach to risk management in Megaprojects. Based on the above argument, it can be argued that the theoretical development of the proposed approach serves as a theoretical lens for the empirical analysis for the current research study. It also provides the basic guideline to the research design and to select and justify the appropriate research methods to collect and analyse the data. To the author's best knowledge, no other research in the area of risk management and Megaprojects has followed a similar systematic procedure to develop a new approach for managing and mitigating risks in Megaprojects, and this is the first attempt to do that.

4.6 Summary

The chapter has theoretically proposed an approach to risk management in Megaprojects by identifying and synthesising the theoretical concepts that underpin both MCRs and CMMs as the fundamental elements to address the current research problem. The chapter has defined a unique list of MCRs that can occur in all Megaprojects and only in Megaprojects. This list comprises five MCRs: Adaptability to Legislative and Political Changes (MCR1), Aligning Stakeholders' Expectations (MCR2), Scaling-up (MCR3), Operability (MCR4) and Incomplete Contracts (MCR5). The chapter has also identified a unique list of CMMs that can be applied across all Megaprojects irrespective of what they are and where they are. This list comprises four possible mitigation measures: ACT (CMM1), PMO (CMM2), COP (CMM3) and NFC (CMM4). The chapter has shown that MCRs and CMMs have shared elements, which provide the theoretical linkages to justify the rationales of the proposed approach of risk management in Megaprojects. The theoretical development of the proposed approach can serve as a theoretical lens for the empirical analysis for the current research study, i.e. to select and justify the appropriate research methods for collecting and analysing the data. Therefore, the derivation of theoretical constructs of the proposed approach can be regarded as the starting point to collect and analyse the data required to address the research problem, hence achieve the research aim and objectives.

Chapter 5 Research Methodology

5.1 Introduction

This chapter introduces the research methodology, which has been applied to achieve the research aim and objectives. The chapter consists of nine sections, including this introduction. Section 5.2 discusses and justifies the adopted research methodology regarding research reasoning, research approach, research method, and data collection technique. Section 5.3 outlines the research process to apply the research methodology by presenting the main activities and the links among them. Sections 5.4 discusses the identification process for MRs. Sections 5.5 discuss the identification process for MCRs. Section 5.6 justifies and discusses the theoretical derivation of the proposed approach. Section 5.7 explains the main activities of the fieldwork study phase by presenting, discussing and justifying the application of Adapted Grounded Theory as a research method to collect and analyse data. Section 5.8 discusses and justifies the application of the Delphi technique to test and validate the research findings. Lastly, Section 5.9 summarises the chapter.

5.2 Adopted Research Methodology

Fellows and Liu [413] defined research methodology as the principles and procedures of logical thought process which are applied to a scientific investigation, whereas research methods concern the techniques which are available for data collection and analysis, and those which are actually employed in a research project. This underlines that a research methodology refers to the overall approach undertaken to explain and justify what, why and how research methods were chosen. Therefore, research reasoning, research approach, research method, data collection technique and the means of analysis are all part of the methodology. For the current research purposes, the adopted methodology includes inductive research reasoning, qualitative research approach and Adapted Grounded Theory (AGT) as research methods, and semi-structured interviews as the data collection technique as shown in Figure 5.1. These elements are discussed and justified in detail in the next sections.

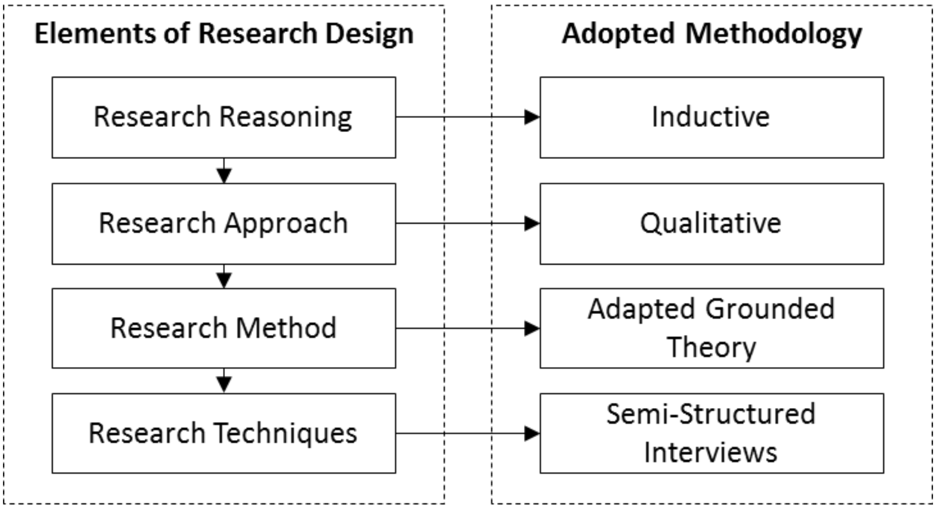

Figure 5-1 Adopted Research Methodology

5.2.1 Adopted Research Reasoning

Walliman [414] defined reasoning as "a method of coming to conclusions by the use of logical argument", and he put forward three types of reasoning: deductive, inductive and a combination of them, which is deductive-inductive. The deductive approach usually begins with a general theory and moves towards inferring a more specific hypothesis which is subjected to empirical scrutiny against observations. The inductive approach, in contrast, starts from specific observations towards detecting patterns and formulating some hypotheses to be explored, ending up in broader generalisations and theories [415]. Regarding this, deductive and inductive can be integrated to form the deductive-inductive type, which involves developing the hypotheses inductively and then testing them deductively; hence deductive-inductive reasoning could enhance the knowledge progress, certainly scientific knowledge practice [414]. The current research study uses inductive reasoning due to its exploratory nature, which aims to improve the delivery performance of Megaprojects by developing a new approach to manage and/and mitigate MCRs in a better way.

5.2.2 Adopted Research Approach

Researchers have to make decisions about selecting the research approach to collect and analyse data to obtain the final results [413]. Creswell [416] defined research approaches as plans and procedures for research that span the steps from broad assumptions to detailed methods of data collection, analysis and interpretation. He argued that research approaches involve the intersection of philosophical assumptions, designs and specific methods. There are three available approaches in conducting any research: qualitative, quantitative, and a combination of both called the mixed-method [185, 413, 417]. The current research has a qualitative focus because it helps to understand and answer primarily what and how questions. Thus, a qualitative approach seems to be better suited to answer the current research questions: what are MCRs and how we can manage and mitigate them better. It also allows researchers to investigate things such as the beliefs, understanding and opinions of people [413]. Again, this is a suitable option since identifying, assessing, managing and mitigating risks essentially rely on the knowledge, judgement, perception and experience of people involved in the project [93, 97, 102, 165]. Qualitative research is also selected as it allows researchers to acquire knowledge that is difficult to acquire by calculation. This is suitable for the current research since the data required to satisfy the research aim and objectives is informative by nature, and needs to be gained from a small sample of experts [15, 142, 163] due to the non-repetitive nature of Megaprojects [69].

5.2.3 Adopted Research Method

According to Bryman [418], a research method is a technique for collecting data, and it is different from research methodology, which relates to the procedures and principles of logical thought processes applied to a study. The literature review revealed nine research methods as being appropriate for the research area of project management: action research, case study, computer modelling, ethnography, experiments, historical, phenomenology, survey and grounded theory [185, 192, 413, 416, 419].

According to Fellows and Liu [413], to select the suitable research method, consideration needs to be given to the research questions, data required to answer these questions, and how this data is to be collected and analysed. Yin [192] identified three conditions that need to be considered when selecting the most appropriate research method: types of research questions, the extent of control an investigator has over actual behavioural events and the degree of focus on contemporary events. Based on the above criteria set by both Fellows and Liu and Yin [192, 413], the adopted criteria to select the research methods for this research study are listed in Table 5.1.

Table 5-1 Criteria for the Selection of the Research Method

Research method criteria	Choices in this study
Types of research questions	The current research study mainly aims to answer "what" and "how" questions, which are suitable to address what MCRs are and how they can be managed and mitigated effectively and differently.
Type of data	The data required is mostly lingual and qualitative in nature.
The extent of investigator control	The scale, complexity and long life cycle of Megaprojects reduce the researcher's control over the investigated phenomenon.
The degree of focus on contemporary events	Megaprojects are a contemporary phenomenon and are quite varied in types and locations, and they are limited in number around the world, and they are unique by definition in different aspects.

Considering the selection criteria listed in Table 5.1, the suitability of each of these nine research methods is discussed and justified in Table 5.2.

Table 5-2 Limitations of other Research Methods

Research Method	Justifications	
Action Research	No	This method is an iterative process where researchers participate in the process under study with practitioners on a particular cycle of activities, in order to identify, promote and evaluate problems and potential solutions [413, 420]. It is inappropriate for the current study since it requires the involvement in the process of risk management of Megaprojects, which is a lengthy process.
Case Study	No	The case study is primarily narrative with evidence, which is largely embedded in individual case contexts [192]. It requires a large amount of in-depth data about particular individual cases rather than the generalisation of outcomes. Therefore, it is not possible for the current research since Megaprojects vary in type, size and location. Further, the other limitation with the case study is the confidentiality of the information of Megaprojects, especially project-specific data, that can be used for quantitative research [183], which can be attributed to the confidentiality of contractual documents.
Computer Modelling	No	Although it is possible to perform some virtual simulations using the existing modelling software such as @Risk, such methods require the availability of sufficient quantitative data with high quality and accuracy to produce meaningful outcomes. However, there are many constraints in gathering sufficient quantitative data on Megaprojects for many reasons. Very often, access to such quantitative data is difficult due to political reasons [183].
Ethnography	No	This method requires the researcher to spend considerable time in the field among the people whose lives and culture are being studied [421]. However, the aim of this study is to improve the delivery performance of Megaprojects by managing and mitigating MCRs rather than

Research Method		Justifications
		focusing on the people involved in this sort of project. Therefore, ethnography is rejected because it is used to study cultural phenomena.
Experiments	No	An experiment is an empirical investigation under controlled conditions designed to examine the properties of, and the relationship between, specific factors [421]. Thus, the most important characteristic of the experimental approach is that it deals with the phenomena of cause and effect [414], both of which can be observed in the field laboratory. For that reason, this method is not considered in this study because the investigator (researcher) has no control over the process of managing and mitigating MCRS. Therefore, it is not possible to conduct experiments.
Historical	No	This method deals with the entangled situation between phenomenon and context but usually with no present-day events [192]. This underlines that such methods seem to be suitable for filling in the gaps in historical knowledge. Accordingly, this method is not suitable for this study because Megaprojects are contemporary phenomena within a real-life context.
Phenomenology	No	This method trying to understand how an individual perceives and constructs their own reality, based on the knowledge and situation they experience [422]. Although this method has the potential to answer how MCRs are being managed and mitigated, it is not considered in this research because managing and mitigating risks do not necessitate the physical involvement of the experts.
Survey	No	Surveys act on the basis of statistical sampling were surveying the entire population is rarely possible, practical or desirable [413]. Because the population tends to be far too large, a study sample needs to be representative to yield enough reliable data about the population at a required level of confidence. A survey is not suitable for this research because of the limited number of experts with experience of risk management and mitigation in Megaprojects.
Grounded Theory	Yes	Rationales for using this method are provided below this table.

Grounded Theory is selected as the most suitable method to collect and analyse data for this research study for the following reasons:

GT is described as an inductive research method, which is dedicated to generating/modify theories by emphasising the importance of empirical fieldwork [423]. This is suitable for the current research study since the research aims to improve risk management in Megaprojects beyond conventional risk management approaches (existing theories) by developing a new approach (new theory) to manage MCRs in a better way.

GT is a qualitative method to collect and analyse data [424], which is suitable for the current research. The rationale behind this argument is that assessing, managing and mitigating risks essentially relies on the knowledge, judgement, perception and experience of people involved in the project, which are qualitative by nature [93, 97, 102].

The strength of GT lies in its ability to describe patterns, to fit different contexts and to explore phenomena where often little understanding of the phenomena already exists. GT allows the analyst/researcher to conduct several data collection rounds and to modify a set of questions as data emerges and is confirmed, which eventually helps to probe in-depth data. This is suitable for this study since managing and mitigating MCRs, in general, rely on the perceptions, attitudes, and experiences of Megaproject experts.

GT is more suitable for small-scale studies and research focusing on human interaction in specific settings [421]. This is suitable for this study since the low number of Megaprojects [37] has implications in that the number of Megaproject experts is relatively small compared to conventional construction projects.

GT provides an understanding of how complex phenomena occur, where the resulting concepts are grounded in the actual reality of the phenomena themselves. This exploratory power of Grounded Theory is appropriate for the current research study due to the complex and uncertain nature of Megaprojects. As Megaprojects occur so infrequently, there is a lack of complete and accurate data, so they cannot be investigated directly.

5.2.3.1 Adaptive Grounded Theory Process

Grounded Theory is a qualitative method to collect and analyse data formally developed by Glaser and Strauss [424] in their book entitled 'Discovery of Grounded Theory'. It is described as an inductive research method, which is dedicated to generating theories by emphasising the importance of empirical fieldwork [423]. In Grounded Theory, theories should be 'grounded' in empirical research by linking any explanations very closely to what happens in practical situations in 'the real world' [423].

However, there two schools of thought or versions to apply the Grounded Theory method. The first version is Classical Grounded Theory, which was founded and explained by Glaser and Strauss [424]. The second version is Modified or Adapted Grounded Theory (AGT), which is addressed and explained by Corbin and Strauss [425]. The former version is more empirically oriented, and it advocates building theories from pure data without any theoretical background. Conversely, the latter version relies on utilising and reflecting the existing theories into a grounding process of data collection. Table 5.3 lists the main differences between the two versions of the Grounded Theory method.

Table 5-3 Comparison between Classical and Adapted Grounded Theory

Aspect	Classical Grounded Theory	Adapted Grounded Theory
Empirically oriented	More	Less
Time-consuming	More	Less
The breadth of data	Large	Small
The depth of data	Less	More
Researcher's intervention (Reflexivity)	Less	More
Preferred context	No data is available	Little data is available

For the current research purposes, AGT is selected as the most appropriate option compared with the classical version essentially because collecting data on managing and mitigating MCRs is too broad to be investigated in the original form as it relies on the judgement and perception of risk practitioners [93, 97, 102]. Hence, using AGT could focus the current research compared with classical GT, which might lead to an open-ended process. AGT includes four key features: constant comparative method, theoretical sampling, coding and categorising, and generating theory [424, 425].

The constant comparison method is one of the prominent features of the Grounded Theory method as a means of analysing the data [421]. Glaser and Strauss [424] described the four stages of this method: comparing incidents applicable to each category, integrating categories and their properties, delimiting the theory, and writing the theory.

Theoretical sampling is defined as "the process of data collection for generating theory whereby the analyst jointly collects, codes, and analyses his data and decides what data to collect next and where to find them, in order to develop his theory as it emerges" [424].

Theoretical saturation is defined as the point when new data that is examined provides no new information in terms of refining the category or of its properties, or of its relationship to other categories [426]. It is the point when the new data seems to confirm the analysis rather than add anything new, and thus, the sampling comes to an end [423].

For coding and categorising, Glaser and Strauss [424] used the word coding to describe the “process of composing a name for what is happening in a particular fragment of data, offering little further elaboration other than data incidents are coded into categories”. In general, the coding process is broken down into three main stages: open coding, axial coding and selective coding [425].

Open coding refers to the process of identifying and developing categories and subcategories in terms of their properties and dimensions [427]. Axial coding refers to the process of identifying the relationships between categories and subcategories, including conditions, cause-and-effect relationships and interactions [427]. Selective coding involves integrating categories and subcategories with a central category and providing sufficient detail and density for the evolving theory [427].

5.2.4 Adopted Data Collection Techniques

Data collection is one of the main elements of any research methodology [101]. Although there are several techniques to collect qualitative data, the most suitable technique should be applied and justified [425]. According to Creswell [416] there are four major data collection techniques in qualitative research: questionnaires, interviews, observations and documents. For the current research purposes, semi-structured interviews are used to collect data to achieve the research aim and objectives. The main rationales behind this choice include its suitability for small samples and exploratory research, ability to probe for in-depth data and its flexibility. According to Denscombe [421], semi-structured interviews can provide rich and deep information, which are suitable for small samples. This is suitable for the current research study since the number of Megaproject experts is relatively small compared to conventional projects [15, 142, 163]. Further, semi-structured interviews are particularly good at extracting data which deals with topics in depth and detail [421], such as how to manage and mitigate MCRs differently in a better way. Moreover, it allows the researcher to modify the interview questions as data emerges and is confirmed [421]. Hence, it offers more flexibility to add new questions related to the subject during the interviews, which is suitable for the current research since managing and mitigating risks requires in-depth information from multiple expert opinions [93, 97, 102].

5.3 Research Process

The research process adopted to achieve the research aim and objectives is illustrated in Figure 5.2.

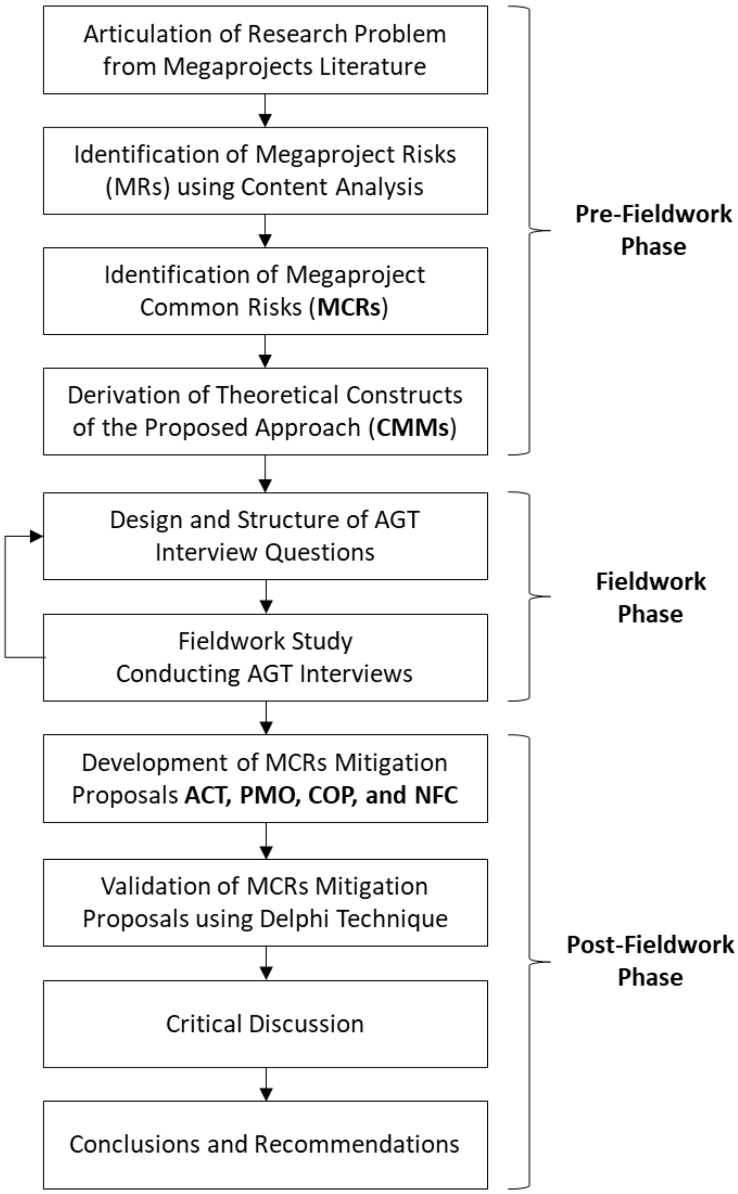

Figure 5-2 Research Process

The research process consists of three phases: pre-fieldwork phase, fieldwork phase, and post-fieldwork phase, as shown in Figure 5.2. The pre-fieldwork phase started with a rigorous literature review in both the Megaproject and Risk Management areas. The literature review showed that many of the conditions for the successful application of conventional risk management approaches were not satisfied in Megaprojects; in particular, problems arose from the lack of complete and statistical data. These constraints severely limit the capability of conventional methods to manage risks in Megaprojects, to the extent that these methods could not produce meaningful and realistic results. It also showed that there is a dearth of research on MCRs and their impact. Accordingly, the literature review helps to identify a knowledge gap, forming the research problem (problem statement), and the articulation of research aim and objectives. In this research study, the research problem is "identifying, managing, and mitigating MCRs in a better way".

To address the research problem, an inductive research approach was needed to generate conceptual insights, especially when there is limited theoretical knowledge about managing and mitigating MCRs. Therefore, the pre-fieldwork phase introduces a systematic approach to identify a list of MCRs from the literature in two phases. In the first phase, MRs were investigated and differentiated from conventional risks by using a systematic literature review supported with content analysis. This phase resulted in identifying 38 MRs, which were used as a source to identify MCRs using a systematic process in the second phase. At the end of the second phase, five MCRs were identified and defined.

Given the inductive nature of the current research study, conceptualising an approach to risk management for Megaprojects to address the research problem is the most appropriate choice. Therefore, the pre-fieldwork phase involves a rigorous literature review to identify a comprehensive list of recommended mitigation measures for Megaprojects. Producing such a comprehensive list was used as the main source to extract and derive a set of mitigation measures that are critical for Megaprojects (CMMs). Therefore, the comprehensive list of recommended mitigation measures was screened into a shortlist of CMMs by evaluating each measure against a set of selection criteria and key success indicators. The shared elements between MCRs and CMMs (theoretical constructs), were then investigated and integrated to generate theoretical linkages which justify the rationales of the proposed approach to risk management in Megaprojects.

The derivation of theoretical concepts that underpin CMMs (ACT, PMO, COP, and NFC) and MCR were used in the field-work phase to gain insight into how Megaproject experts perceive the criticality of MCRs and their management and mitigation suggestions. Therefore, the theoretical development of the proposed approach in Chapter 4 served as a theoretical lens for the empirical analysis for the current research study, i.e. to select and justify the appropriate research methods for collecting and analysing the data. This means, the derivation of theoretical constructs of the proposed approach can be regarded as the starting point to collect and analyse the required data in the fieldwork study phase to address the research problem, hence achieve the research aim and objectives.

Once MCRs and their possible CMMs proposals were identified, which both represent the fundamental elements of the proposed approach, the existing research methods in the project management arena were reviewed and compared to determine the most suitable method to achieve the research aim and objectives. According to the complex nature of Megaprojects and the data required to solve the research problem, Adapted Grounded Theory (AGT) has been adopted and justified to collect and analyse the required data from the fieldwork study. Accordingly, semi-structured interviews were selected as the main technique to collect primary data under the AGT method. AGT interview questions were structured, designed and formulated in accordance with the four CMMs proposals (ACT, PMO, COP and NFC).

Once the AGT questions were drafted, AGT semi-structured interviews were arranged with Megaproject experts in the fieldwork phase to collect high-quality data about how to manage and mitigate MCRs collectively using the suggested CMMs. The collected data was analysed using a systematic process of open coding, axial coding and selective coding procedures suggested by Corbin and Strauss [425]. At this fieldwork phase, documentation was applied as a supplementary technique to collect data to fill in gaps that appeared during the analysis. Once all the data was analysed, the empirical findings were discussed and compared with the literature review in the post-fieldwork phase to design and develop a new approach to risk management of Megaprojects. This proposed approach was shaped based on the understanding and interpretation of the empirical research findings, which consists of four MCR mitigation measures proposals (ACT, PMO, COP and NFC), as discussed in Section 7.4. To validate the proposed approach, the Delphi technique was selected and justified as the most appropriate method. Three rounds of Delphi semi-structured interviews were conducted with a Megaproject experts' panel to ensure that the proposed approach is complete, correct, practical and applicable, as discussed in Section 7.5. The validation findings revealed that a consensus was reached about the validity of the four components of the proposed approach: ACT, PMO, COP and NFC. Based on the discussion of the validation results, conclusions, implications for theory and practice, and recommendations for future research were derived.

5.4 Identification of Megaprojects Risks

This section aims to identify a comprehensive list of MRs. In order to conceptualise and synthesise the existing body of knowledge of risks in Megaprojects, the content analysis method is adopted in this reassert study for four reasons [428]. First, content analysis has the potential to disclose many 'hidden' aspects of what is being communicated through the written text [423], and this is very important for the sake of this research since risk can be defined, understood and interpreted differently among practitioners and academics. Second, the accessibility of the data is a notable characteristic of content analysis compared with obtaining data through experimentation in the laboratory, questionnaires, interviews or in artefacts used as documentary evidence [423, 429]. Third, given the long life cycle of Megaprojects, using real-time data collection techniques such as observation, interviews and questionnaire can be a time-consuming option [64]. Hence, content analysis is also a more feasible method to collect secondary data about risk in Megaprojects. Fourth, because content analysis depends on reviewing a large amount of textual material, the outcome of this process could be less biased than the outcomes of other techniques such as questionnaire surveys or interviews [429].

Content analysis is defined as a research method for making replicable and valid inferences from texts (or other meaningful matter) to the contexts of their use [429]. It has emerged as a powerful method that may be used for analysing, either qualitative or quantitative data in both inductive and deductive reasoning research [430]. It has been introduced as an analytical data technique that is applicable in project management research [413].

The content analysis has utilised widely in the literature to collect and analyse qualitative data. For example, Thamhain [24] used the content analysis to analyse the potential contingencies and risk factors impacting the performance of complex projects. Similarly, He *et al.* [431] used the content analysis to extract common measures for Megaprojects from their literature review, to design and develop a complexity measurement model. Patanakul [47] also applied the content analysis of multiple governmental reports on the management of large-scale IS/IT projects, identify the common problems and causes leading to poor performance in such projects. Ninan *et al.* [432] applied the content analysis to explore and identify mitigation strategies that Megaproject teams develop in practice to manage external stakeholders in this sort of project. Sanchez-Cazorla *et al.* [433] performed the content analysis to systematise risks in Megaprojects by focusing on risk identification as the first step of a risk management process. Keizer and Halman [434] applied content analysis to concludes which risks are most characteristic for radical innovation projects. Keers and van Fenema [435] used content analysis systematically to analyse the transcriptions of interviews with key managers of a public organisation to explore and find instances of potential risk scenarios and factors in their immediate context in public-private partnership projects.

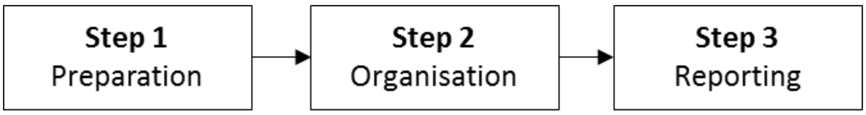

Figure 5-3 The Content Analysis Process

The above studies underline that content analysis has the potential to identify and categorise project risks; hence, it is more suitable than other methods to identify MRs for the current research study purposes. Content analysis generally follows a logical and relatively straightforward procedure [423]. This study follows the approach of content analysis proposed by Elo and Kyngäs [100], which consists of three steps, as shown in Figure 5.3.

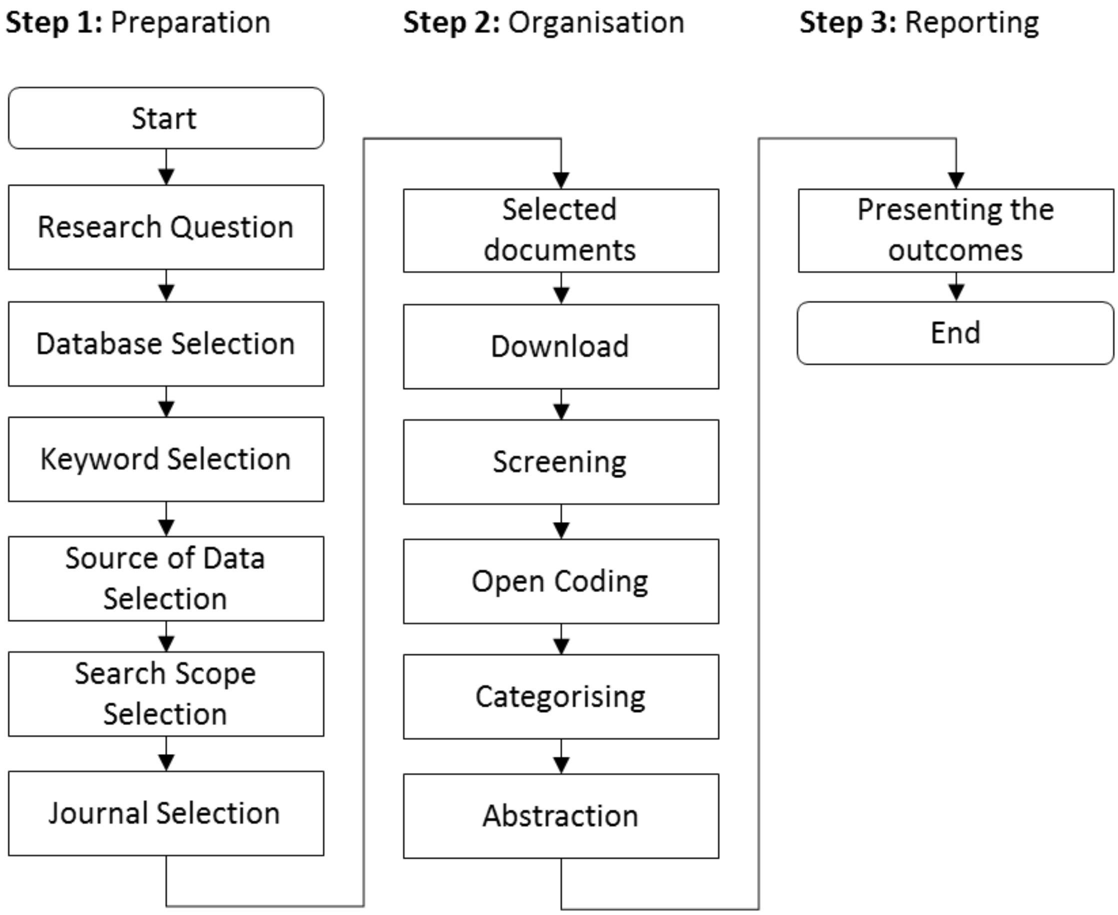

Figure 5-4 The Adopted Content Analysis Procedure

Step 1 (preparation) aims to identify, select and prepare the unit of analysis [100]. In other words, preparation is about identifying the textual material to be analysed [413]. The unit of analysis can take different forms depending on the research question [436]. It may be a part of or all the text data, observations, letters, portion of pages or words, journal articles, books, transcripts of interviews, etc. [100, 436]. Step 2 (organising) involves three sub-steps: open coding, creating categories and abstraction [100]. Open coding is the process of disaggregation of data into units [425], and within the context of content analysis, it means that the notes and headings are written in the margins of the textual content while reading it [100]. At this step, the analyst needs to read through the written material and write down as many headings as necessary in the margins to describe all aspects of the content [425]. Then, the analyst needs to clearly articulate categories to examine and navigate the content. Creating categories aims to compress a large number of texts into fewer content-related categories. Step 3 (reporting) involves reporting the analysis process results with sufficient detail so that readers have a clear understanding of how the analysis was carried out and its strengths and limitations [100]. In this research study, these three steps are followed as shown in Figure 5.4, and are discussed and justified in the following sections.

5.4.1 Step 1 – Preparation

The aim of the preparation step is to select the unit of analysis, as mentioned before, in Section 5.4. In this research study, the preparation step involved five steps, as shown in Figure 5.4. The preparation step started with the formulation of the research question, which can be articulated through the identification of the knowledge gap. In the current research, one of the research objectives to fill this knowledge gap is to identify the common risks leading to a poor delivery performance in Megaprojects. To address this objective, the research question is articulated: *What are MCRs?* The rationale behind this question is to understand the definition of MCRs in order to find a better way to manage and mitigate them for existing and future Megaprojects. To answer this question, there is a need to investigate the literature content on Megaprojects in sufficient depth. The rationale behind this decision is because collecting data from literature about risks in Megaprojects can be regarded as an efficient and fast technique compared with real-time methods such as observation or surveys. The reason for this choice is that analysis of the content of what is published reveals what is thought important and disseminated [206]. The content of material published on risk management in Megaprojects by both academics and practitioners normally reflects what is important, significant, frequent, and up to date regarding the Megaproject delivery performance. Therefore, if a particular risk is identified, mentioned, assessed or evaluated by most academics or practitioners in a particular unit of analysis, then that risk is very critical to Megaprojects success.

Therefore, the selected unit of analysis for the current research is the relevant documents about risk management in Megaprojects. To find such documents, five steps were conducted to refine and screen the data, namely: database selection, keyword selection, source of information selection, journal selection, and search scope selection, as shown in Figure 5.4. The selection criteria for each of these five steps are listed in Table 5.4 and are discussed and justified in the following sections.

Table 5-4 Preparation Framework

Selection Aspect	Adopted Selection
Database	Scopus, https://www.scopus.com
Keywords	“megaprojects” or "mega projects" or "mega construction" or "mega infrastructure" or "major construction" or "major infrastructure" or "major projects" or "large scale projects" or "large scale construction" or "large scale infrastructure" or "complex construction" or "complex infrastructure" or "complex projects" and "risk identification" or "risk assessment" or "risk perception" or "risk allocation" or "risk ranking" or "risk prioritising" or "risk factors" or "project risks" or "major risks”.
Source of Information	Peer-reviewed academic journals.
Journals	The journals listed in Appendix A were thus selected as target journals.
Search Scope	The search scope was selected to cover the period from 2000 to 2018.

5.4.1.1 Database Selection

In the preparation phase, only one academic database, namely, Scopus, was utilised to identify the journals with the largest number of related papers published. The rationale behind this decision is because Scopus claims to be one of the largest online abstract and citation databases of research literature in the world, which covers over 10,000 journals [49, 437]. Further, Scopus provides access to most English language project management periodicals, standards of practice, government publications, research instruments and patient education material. Therefore, Scopus is used by many researchers to conduct literature reviews in the area of Megaprojects, Risk Management and Project Management. For example, Hu *et al.* [49] utilised both Scopus and Web of Science (WoS) in a comprehensive exploratory desktop search to investigate the status and the trends in Megaproject research. Similarly, Irimia-Diéguez *et al.* [48] conducted a systematic review using Scopus in addition to another two databases to establish state of the art in risk management in Megaprojects.

5.4.1.2 Keyword Selection

Different studies use different terminologies to describe Megaprojects, such as complex Mega-projects, large-scale projects, large engineering projects, major projects, complex projects, giant projects, jumbo projects and Megaprojects. Based on the adopted definition of Megaprojects, the common keywords for Megaprojects listed in Table 5.4 were used in the Title/Abstract/Keyword fields to search. In addition, to these terms, several risk management terms were also utilised to screen the search outputs, as listed in Table 5.4.

Three terms, “major” or “mega” or “large scale”, were used with three other terms, “construction” or “infrastructure” or “projects”, to describe Megaprojects such as “major construction” or “mega infrastructure” or “large scale projects” and so on. The terms “giant projects” or “jumbo projects” or “giga projects” or “tera projects” were excluded from the search because they are uncommon in the literature. Although the term “complex projects” covers Megaprojects, it also covers small-scale projects with high complexity such as small nuclear reactors and hospitals, and therefore, it was also excluded. In addition to the terms for Megaprojects, the terms "risk identification" or "risk allocation" or "risk ranking" or "risk prioritising" or "risk assessment" or "risk perception" or "risk factors" or "project risks" or "major risks" were also used in the search engine.

The Boolean “OR” was used between the common keywords for Megaprojects to ensure that at least one term must appear in the search. It was also used between the risk management terms for the same previous purpose. The Boolean operator “AND” was used with the search field of risk management terms to ensure the Megaproject keywords must appear with the risk management terms, for example, "risk identification" AND “major projects”. At this stage of search and according to the selection of the key common words, 642 documents appeared in the search results. These documents were screened further in the selection of the sources of information.

5.4.1.3 Source of Information Selection

In terms of the source of information, the focus of the current review was on peer-reviewed academic journal articles. Book reviews, editorials and papers for conference proceedings were excluded from the review. The rationale behind this decision is because academic journals are the major outlets for the research efforts of risk management in Megaproject scholars around the world. Further, the content of articles is less biased compared with other sources of information such as books in terms of reflecting the author's viewpoint and perspective on a particular issue in the project management discipline [206]. Moreover, the higher-profile features of Megaprojects (scale of cost and impact) have placed heavy implications on the confidentiality of commercially sensitive information; therefore, it was a challenging task to identify risk from other sources such as industrial case studies or government documents. After scoping down the search into journal articles only, 285 documents appeared in the search results.

5.4.1.4 Search Scope Selection

Regarding the search scope, the search process of the content analysis draws on the journal papers that were published from 2000 to 2018. This timeframe was deemed adequate for capturing a wide variety of research on Megaprojects, and hence to identify MRs. It was also selected because Megaprojects have become an emerging area in the field of construction engineering and management since the early 2000s [49]. A recent study that used the Scopus database to search for the term "Megaproject" found that the number of publications resulting from this search increased significantly from 2003 [150], which means that the development of Megaprojects also increased from the 2000s. Irimia-Diéguez *et al.* [48] also used a timeframe that started from 2000 to examine academic journals and conference papers published in three databases, Web of Science, Scopus, and ABI. After selecting the search scope, 251 documents were found.

5.4.1.5 Journal Selection

The search results revealed that the International Journal of Project Management, Journal of Construction Engineering and Management, Construction Management and Economics, Journal of Management in Engineering, Journal of Infrastructure Systems, and Transportation Research Record published the largest number of papers. However, only the peer-reviewed academic journals that are listed in Appendix A were included in the research. The rationale behind this selection is these journals publish the majority of academic research focusing on Megaprojects, risk management and project management. Further, these journals are regarded as the most relevant in the systematic review studies in the field of project management. Accordingly, and after choosing the above-mentioned journals, only 68 documents appeared in the search, and these were selected to be analysed in the next step of the content analysis process.

5.4.2 Step 2 – Organising

In this research, the organising step involved three steps: open coding, creating categories and abstraction, which are discussed and justified in the following sections [100]. However, in order to conduct these steps, another two steps were taken: document downloading and document screening, as shown in Figure 5.4, which also are discussed in the following sections.

5.4.2.1 Document Download

After the preparation and search phase was finished, the 65 identified documents needed to be selected and downloaded in order to be organised and analysed. However, only 57 of the 65 documents were downloaded due to restrictions from their publishers.

5.4.2.2 Document Screening

Each one of the 57 documents was carefully reviewed in order to screen those relevant to the research question. It was found that the documents could be divided into four sets. Set 1 comprises the documents in which the results of the empirical study are described. In this set of documents, it was easy to identify the risks because the authors provided a summary of risks in the form of a list or a separate paragraph. Set 2 comprises the documents in which the authors (practitioners or academics) have indirectly described the risks based on their wide range of experience. Set 3 comprises the documents in which Megaproject failure is discussed, but the authors did not provide a summary of risks behind the failure. Therefore, it was a tricky task to identify the risks in the second and third sets of documents because there was no clear articulation of these risks. Accordingly, documents in sets 2 and 3 were excluded from the content analysis to avoid misunderstandings and misinterpretations. Lastly, set 4 comprises documents that are not relevant to the research under investigation, for example, documents in which the elements of the risk management process are discussed rather than the risks being identified or listed. Therefore, the documents in set 4 were also excluded from the content analysis. After this screening process stage, a total of 17 documents were identified as relevant for subsequent analysis, as listed in Appendix B.

5.4.2.3 Open Coding

At this stage of the analysis, each one of the 17 documents was read through to identify any risk that could potentially affect Megaproject delivery performance. Once a risk was identified from the document text, a code (name) was developed to link that risk in the document, as shown in Figure 5.5. Therefore, each document was read through several times to make sure that all the risks mentioned in that document were captured, understood and reported appropriately. Each code was then supported by a reference citation to evidence of the coding process. A list of risks (codes) was then provided for each document and printed out on A4 paper for use in the categorising stage, as shown in Figure 5.5. For example, after downloading the paper by Boateng *et al.* [69], the whole document was printed out in order to be manually investigated by the main researcher. The open coding stage was conducted by searching on any risk (code) explicitly mentioned in this document. It was found that, in this particular document, the authors provided a summary list of risks associated with Megaprojects; hence, each risk in this list was coded separately. For example, the risk of “legislative/regulatory changes” was found in the list, and therefore it was coded under a new code, namely “adaptability to legislative changes”. Giving a precise code to each risk is an essential step to explicitly clarify between the four elements of risk definition, namely risk title, risk event, risk sources, and risk consequences. In this example, the risk title is “adaptability to legislative changes”, whereas the risk event is “the lack adaptability of Megaprojects to legislative changes”. In contrast, the term “legislative/regulatory changes” is more appropriate to refer to the sources of that risk because some legislative changes might be a source for opportunities rather than threats. The risk consequences refer to the potential impact on Megaproject performance that could result from the lack of adaptability to legislative changes such as cost and time overrun. Therefore, the documents are carefully read, understood and interpreted in order to produce an accurate list of codes. At the end of this stage, hundreds of codes were derived from the 17 documents and will be grouped into a number of categories, as discussed in the next step.

5.4.2.4 Categorising

The categorising stage aims to classify data/codes that share similar features or properties into broader higher-order categories in order to reduce the number of categories [101], as shown in Figure 5.5. In simple terms, each main category needs to contain codes that share a commonality [429]. According to Dey [101], when the analyst reaches this stage, he/she needs to decide based on his/her interpretation, which codes to put in the same category. Therefore, in the current research study, it was a tricky task to determine to which main category a given risk/code belongs. The reason behind this is because different authors may use different terms to identify the same risk. The other reason is risks (codes) may be dependent on other risks [438], which can create huge duplication and replication in reporting risks. Therefore, and in order to avoid risk duplication and replication, each risk (code) was carefully investigated in-depth to capture the definition intended by the author. This was achieved by searching on the definition of that risk (code) in the document under analysis to find out the precise meaning of risk as intended by the author. Further, each risk (code) was compared with the other risk (code) within each document to identify similarities and differences.

In the current research, the identified risks (codes) in the open coding stage that contributed to the same meaning were grouped under a single category with a unique ID such as MR1, as shown in Figure 5.5. For example, codes such as a "delay due to legalisation changes", "lack of project adaptability to new health and safety legislations", and "the adverse impact of law changes on project outputs" all share the same source of risk, namely "legislative changes". Therefore, these codes can be grouped together under a broad category, namely "the adaptability to legislative changes". Unforeseen weather conditions, adverse weather, unforeseen geotechnical issues, or site/location conditions are other relevant risks (codes) and are grouped under another category, namely "unforeseen weather/geotechnical conditions". The categorising process was repeated until distinct sets of categories were obtained, where each category represents a distinctive MR, as shown in Figure 5.5. At the end of this stage, 38 unique categories were formulated as MRs, which are then defined and described in Appendix C.

5.4.2.5 Abstraction

The aim of the abstraction stage is to formulate a generic description of the research topic through generating categories, where each category needs to be named using content-characteristic words [100]. In this research, the abstraction process was continued until all codes and categories had been extracted from text documents and organised, as shown in Figure 5.5.

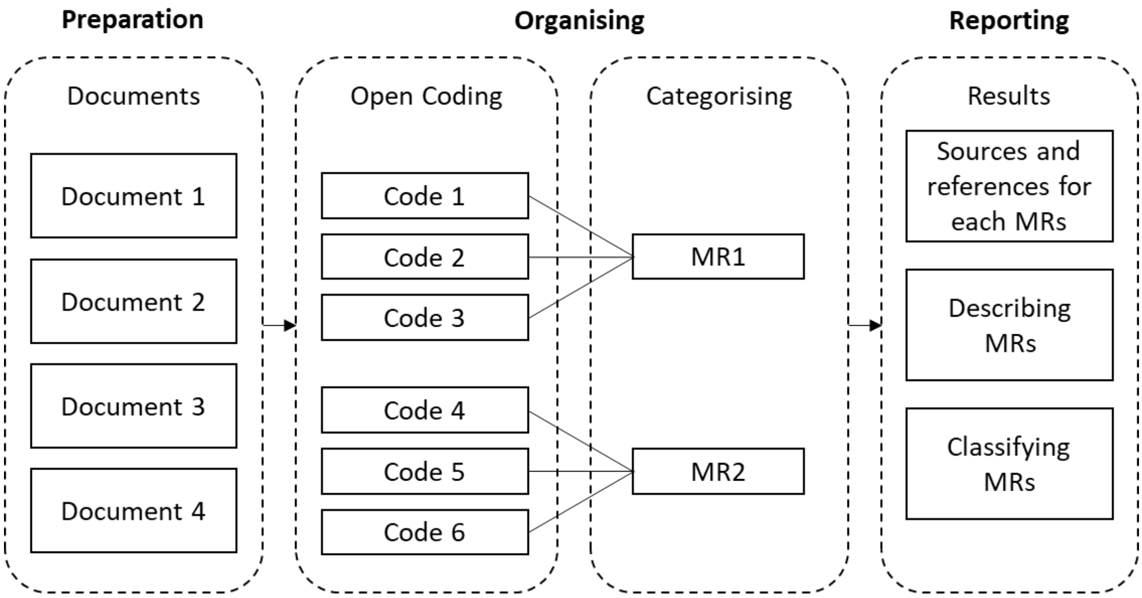

Figure 5-5 Abstraction Process of Content Analysis

5.4.3 Step 3 – Reporting

After conducting the comprehensive literature review and content analysis and after removing the duplicates and merging similar risks, a total of 38 potential MRs were identified, as listed in Appendix B. The sources used in the content analysis (selected documents or references) to reach this comprehensive list of 38 MRs are also listed in Appendix B. The identified 38 MRs are briefly described and classified in Appendix C and Appendix D respectively. The identified 38 MRs will be utilised as the main source to extract and identify MCRs.

5.5 Identification of Megaproject Common Risks

This section aims to identify a set of MCRs from the literature as one of the fundamental elements to establish and conceptualise a new approach to risk management in Megaprojects. Many studies have been conducted to identify risks associated with Megaprojects [23, 51]. For example, Wang and Pitsis [439] used a questionnaire survey to identify crisis-critical factors in the antecedents of Megaprojects in China. Chapman [67] applied a framework for examining the dimensions and characteristics of complexity inherent within rail Megaprojects. Boateng *et al.* [69] used a theoretical framework to summarise and report Megaproject risks from the literature and provided an analytical network process model for prioritising these risks in Megaprojects. Lam [23] provided a sectoral review of risks associated with major infrastructure projects. Patanakul [47] identified common problems in managing IS/IT Megaprojects in the public sector only, whereas Megaprojects can also be partially or fully funded by the private sector. Allport and Ward [82] conducted interviews with experienced industry practitioners on the underlying risk drivers and the factors that influence the effective management of operational risk in Megaprojects. The above studies underline that traditional literature on Megaprojects tends to identify risks from a general perspective without considering how these risks are common to all Megaprojects [23, 46, 47]. Further, a serious weakness with the above studies is that they failed to define and distinguish MCRs from conventional risks.

However, although the risk management literature is extensive, there is a dearth of studies that investigate risks in Megaprojects and differentiate these from risks in conventional projects [440]. In fact, there is a dearth of research on MCRs and their impact [409]. Most of the existing studies in the field of risk management tend to use the risk frequency, i.e. how frequently risk is identified in the selected articles/case studies, to reflect how common the risks are in a particular project [440]. However, such an approach could mislead the decision-making process because it does not reflect the actual significance of the risk to the project's delivery performance. Therefore, it would be of great importance to identify and integrate MCRs into a single approach to generate a wider picture, as well as to analyse their interrelationships. This is supported by Dikmen *et al.* [441], who argued that a pre-defined list of common risk sources might assist practitioners in identifying risks, which in turn may help them to develop a common language about risks and easy retrieval of similar risk sources when needed. In fact, identifying common risks enables practitioners to lower the possibilities of regular risks; hence, prevent such risks from occurring [442].

This section, therefore, aims to identify MCRs to address the knowledge gap by introducing a new approach of two phases, as shown in Figure 5.6. In phase one, the research was able to identify a comprehensive list of 38 possible MRs by using a systematic literature review supported with content analysis, as shown in Section 5.4 and listed in Table 2.3. This comprehensive list of MRs will be used as the main source to select MCRs, which is the goal of the current phase. In this regard, the current research proposes a process of four steps to select MCRs based on a combination of tools and methods including risk definition, risk classification [72], risk breakdown [128] and risk aggregation [443], as shown in Figure 5.6 Each one of these four steps is discussed and justified in the following sections.

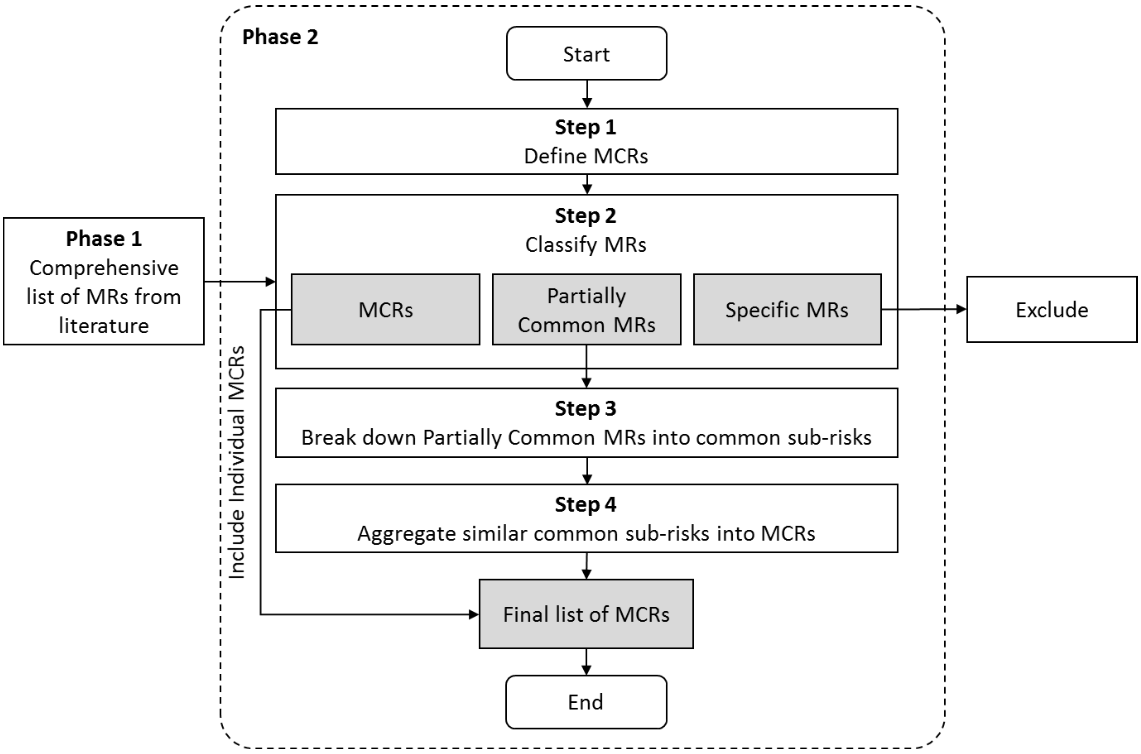

Figure 5-6 MCR Identification Process

5.5.1 Step 1 – Define Megaproject Common Risks

Defining risk is an important step in any risk identification process since it helps risk management practitioners to understand the risk associated with their projects. According to Yates [444], risk needs to be defined and properly apportioned in order to be understood by project parties. Smith *et al.* [102] argued that many projects suffer from poor definition and inadequate risk analysis. This argument confirms the importance of providing a precise and consistent risk definition in any risk management process in order to reduce any vagueness and misunderstanding among project parties [445]. However, studies show that there is no precise definition for MCRs; instead, very often, there is a lack and inconsistency among practitioners/academics to define what constitute MCRs [175]. Therefore, the current step (Step 1) aims to define MCRs in order to aid the identification process of these risks. For the current research purposes, MCRs are defined as risks that are common to all Megaprojects and only Megaprojects, irrespective of type, size, duration or complexity, yet they can be manifested differently from one Megaproject to another, which could result in any kind of negative impact to project outputs. The rationale behind this definition is that, as long as all Megaprojects have shared features such as the huge scale, high complexity (technically and organisationally), enormous number of stakeholders, and lengthily delivery and development processes [6, 28], the related MRs with these features are common to all Megaprojects and only Megaprojects.

5.5.2 Step 2 – Classify Megaproject Risks

Risk classification is considered an important step in the risk assessment and management processes, as it attempts to structure the diverse risks that may affect a project [438]. Several authors have attempted various approaches to classifying risks in Megaprojects. For example, Bruzelius *et al.* [29] distinguished between only four risks in Megaprojects: cost, demand, financial market and political. Lessard and Miller [66] classified risks in Megaprojects into three categories, namely technical risks, market risks, and social and institutional risks. Merna and Smith [446] classified risk in privately financed projects into two broad categories: global and elemental. Prasitsom and Likhitruangsilp [447] identified and classified risks in international construction joint ventures in Thailand into three categories: internal, project and external. Li *et al.* [448] showed that the key aspects of risk classification could be listed into three levels: macro level, meso level and micro level, based on a meta-classification scheme. Perry and Hayes [71] provided an extensive list of factors and classified these factors into nine sources: physical, environmental, design, logistics, financial, legal, political, construction and operational. Some authors, like Wood and Ellis [176], classified risks according to the stages within the projects development process.

However, it is evident that the above classification systems lack the means of classifying MRs properly by not classifying them according to their commonality across Megaprojects. These limitations could be attributed to the fact that there is neither common risk terminology accepted across Megaproject disciplines and departments nor a systematic approach to identify and select MCRs [33-36]. This conventional view of MRs should be replaced by a more generic view, requesting a more generic classification. Therefore, for the current research purposes, a simple classification of MRs is proposed, where a distinction is made among MRs common to all Megaprojects and only Megaprojects (MCRs), MRs partially common to Megaprojects (Partially Common MRs), and MRs specific to Megaprojects (Specific MRs), as shown in Table 5.5. These categories are defined to provide assessment criteria to evaluate whether a given MRs element is common, partially common or specific to Megaprojects.

Different from MCRs, which is defined in the previous section, Specific MRs can be defined as risks that could occur to a particular type of Megaproject and/or occur in a particular area. Specific MRs can arise from the way a project is managed or from events in its immediate internal environment [99]. In contrast, Partially Common MRs can be defined as risks that are not common to all Megaprojects but which have some elements common to all Megaprojects; hence they are attributable to common causes or (sub-risks) but not the whole risk. This argument is supported by Allport and Ward [82], who argued that risk drivers (sub-risks) are often similar across different sectors of infrastructure projects. To show how the proposed classification system is applied in this study, Table 5.5 provides one example for each category.

Table 5-5 Classification of MRs

Category	Example
MCRs	**Incomplete Contract:** is a typical example of an MCR, which is defined as contract deficiency in recognising Megaproject boundaries due to their massive scale, turbulent life cycle and inherent complexity; hence, it lacks the ability to accommodate the necessary provisions, actions and mechanisms to effectivity manage risks in Megaprojects. The rationale behind this classification is that all Megaprojects are incomplete contracts by definition due to common factors such as turbulent-lengthy life cycle [64] indefinite scope [197] and stakeholder diversity [47, 288].
Specific MRs	**Adaptability to Unforeseen Site Conditions:** is a typical example of a Specific MR. The main rationale behind this decision is that this risk is very sensitive to both project location and project type, and therefore, it cannot be considered as a common risk to Megaprojects. For example, in subsurface Megaprojects like tunnelling, there are unforeseen site conditions associated with high uncertainties compared with above-ground Megaprojects like bridges and highway-rail systems [449].
Partially Common MRs	**Adaptability to Design Changes:** is a typical example of a Partially Common MR. The rationale behind this argument is that, although this risk is not common to all Megaprojects, it involves elements that are common to all Megaprojects. For example, the design changes can be attributed to the uncertainties associated with untested and unproven technology that is part of the development process for all Megaprojects [65]. Further, the turbulent nature of the delivery environment of all Megaprojects associated with frequent changes in laws, policies, stakeholders, client's requirements, or market preferences has a huge influence on design changes [23].

By applying the proposed risk classification, three groups of MRs are generated, and the outputs are listed in Appendix D.

5.5.3 Step 3 – Break Down Partially Common MRs to Sub-Risks

The current step (Step 3) aims to break down the Partially Common MRs identified in the preceding step into their main sub-risks. For the current research purposes, the term "sub-risks" is used to describe the elements that could lead to the occurrence of a risk, which could be expressed by other terminologies like risk factors [102], risk drivers [450], risk causes [123] or risk attributes [451]. The first rationale behind the current step is that large and complex systems like Megaprojects are difficult to be comprehended as a whole [197]; hence, the tendency is to break down such systems into smaller and more manageable subsystems [197, 410]. The second rationale is to identify sub-risks that are common to all Megaprojects and allow them to be aggregated into a single MCR [452]. This is supported by Molenaar [90], who argued that, if the risk analyst is not able to determine if a risk or opportunity is independent, he/she needs to combine it with its correlative events to form one event that can be modelled or treated independently. Break down risk is also used to present a project in hierarchical, manageable and definable packages in order to provide a basis for project planning, communicating and reporting [453]. Similarly, Hillson [454] argued that, by breaking down risk, the project could be presented in hierarchical, manageable and definable packages, which can provide a basis for project planning, communication, reporting, and accountability.

As a tool, risk breakdown is widely accepted and applied by both academics and practitioners in the area of risk management — for example, Marle and Vidal [455] break down a list of global risks into smaller and more manageable clusters to facilitate the coordination and management of risks. Derakhshanfar *et al.* [456] used a risk breakdown structure to systematically identify and group risk delay terminology and taxonomy in construction projects. Tah and Carr [438] used a hierarchical risk breakdown structure representation to develop a formal model for qualitative risk assessment for construction projects. Ebrahimnejad *et al.* [453] applied a risk breakdown structure in order to organise and structure risks in Build Operate Transfer (BOT) projects in order to facilitate understanding, communication and management of these risks. Mojtahedi *et al.* [457] developed a new procedure for classifying potential risks based on a project work breakdown structure. Mousavi *et al.* [458] applied a risk breakdown structure (RBS) in order to organise different categories of the project risks for highway projects; hence, to mitigate these risks.

To illustrate the breakdown process, the literature is used to identify the main elements that lead to the occurrence of two Partially Common MRs, which some of them could be common to all Megaprojects as shown in Table 5.6. By following the same breakdown example in Table 5.6, the rest of the Partially Common MRs are subdivided into their main elements.

Table 5-6 Break Down of Partially Common MRs

Partially Common MRs	Sub-risks
Adaptability to design changes	• The complex nature of all Megaprojects in both technical and organisational aspects is the main source of design changes [67, 150]. • A large number of interfaces and contracts make all Megaprojects associated with ill-defined contracts with a lot of gaps, which makes Megaprojects suffer from frequent design changes to fills the established gaps in contracts. • The design changes can also be attributed to the uncertainties associated with untested and unproven technology that involves in all Megaprojects development process [65]. • The turbulent delivery environment of all Megaprojects associated with frequent changes in laws, policies, stakeholders, client's requirements, or market preferences has a huge influence on design changes [23].
Financial difficulties	• The huge cost of Megaprojects, which usually defined in billions of pounds needs substantial funding by the government [137], which represents a significant challenge to finance this sort of projects. • Further, because Megaprojects are incomplete contracts by definition [6], the overall cost of is extremely difficult to discern as "fixed-price" contract, which may hide additional cost increases and inflated claims by other parties; hence more financial issues.

5.5.4 Step 4 – Aggregate Similar Common Sub-Risks

The current step aims to aggregate similar common sub-risks identified in the preceding step into aggregated major themes (MCRs). The rationale behind this step is to squeeze the long list of Partially Common MRs into a short and focused list of MCRs. Using risk aggregation is supported by Smith *et al.* [102], who argued that it is a good practice to identify the main risks separately and combine most of the other elements and treat them as a single risk. By aggregating the similar common elements in Megaprojects, practitioners will be able to concentrate on analysing, managing and mitigating them effectively for future Megaprojects [459]. Molenaar [90] argued that, if a risk analyst/practitioner cannot determine whether a particular risk is independent or not, that risk could be aggregated with its correlative events to form one major event that can be modelled independently. Thus, risk aggregation can help practitioners to obtain a complete understanding of risk in their projects [460]. Meulbroek [461] argued that, by aggregating different categories of risks, different ways of managing risks could be combined to achieve a common objective.

As a tool, risk aggregation is a common principle that has been applied at least since the dawn of the insurance industry [462]. However, it is also recognised and applied by academics and practitioners in the area of risk management. For example, Tah and Carr [438] suggest the use of “risk centres” for aggregating risks in order to focus the attention of the project managers onto particular areas of the project. Cioffi and Khamooshi [452] presented a method for combining risk impacts and estimating the overall impact, at a given confidence level, leading to an appropriate contingency budget. Dikmen *et al.* [463] used fuzzy risk assessment to rate cost overrun risk in international construction projects by including the concept of risk aggregation in their study, by which the fuzzy sets that represent the output of each rule are combined into a single fuzzy set. Marle and Vidal [455] applied the concept of risk aggregation into a global list of risks by the aggregating numerical value of cause or effect for each risk into an aggregated cause/effect matrices. Similarly, Fang and Marle [464] used risk aggregation to prioritise risks by combining their probability and impact to suggest and test mitigation actions; hence, to support project managers in making decisions regarding risk response actions.

To illustrate the aggregation process, two sub-risks of two Partially Common MRs listed in Table 5.6 are used as an example. The first sub-risk is the scale of interfaces and contracts, which means that Megaprojects can be associated with ill-defined contracts. This requires frequent design changes to address and repair such incompleteness. The second sub-risks is the scale of the cost of Megaprojects, which is usually defined in billions of pounds, and which represents a significant challenge to finance this sort of project without substantial funding by the government [137]. It can be seen that these two sub-risks are strongly connected to the massive scale of Megaprojects, which is an element that is common to all Megaprojects. Thus, these sub-risks can be aggregated into one major theme, namely Scaling-up. As an MCR, Scaling-up involves sub-risks that are associated with the scale of Megaprojects in terms of cost, size, scope, duration, complexity, uncertainty, and impact on society, economy and environment [42, 63, 465].

By applying the same aggregation concept, an extensive review of common sub-risks is undertaken, and the findings used to assign these sub-risks as mostly belonging to one of two distinct MCRs. The first one is called Adaptability to Legislative and Political Changes, which involves sub-risks associated with external political events outside the project boundaries; hence, they are beyond the control of the project management team [24, 282, 466]. The second one is called Aligning Stakeholders' Expectations, which involves sub-risks associated with the multiple stakeholders involved in Megaprojects with their different perceptions, needs, goals and agendas towards project success [47, 67, 248]. The final list comprises five MCRs: Adaptability to Legislative and Political Changes (MCR1), Aligning Stakeholders' Expectations (MCR2), Scaling-up (MCR3), Operability (MCR4), and Incomplete Contracts (MCR5), as provided in Table 4.5.

5.6 Theoretical Derivation of the Proposed Approach

Authors like Miles *et al.* [467] have argued that the process of building and conceptualising theories generally relies upon general constructs that act as categories for storing information. Timonen *et al.* [468] supported this argument by contending that researchers can use inductive research such as the Adapted Grounded Theory (AGT) method by starting with a theoretical orientation (obtained from the literature). Therefore, conceptualising the existing theories through developing theoretical constructs is an important step for inductive research studies, which enables the researcher/analyst to use these constructs as tools to collect data. Thus, it is important to underscore that, when researchers choose to specify substantive theoretical constructs prior to their empirical work, they are deciding to let prior theory set the terms for what they will find – even if their research challenges that theory [426]. The above argument underlines that inductive research methods such as AGT are strongly connected with conceptualising theories. This is confirmed by Timonen *et al.* [468], who argued that the goal of AGT is to reach "saturation" of the theoretical constructs through data saturation, where no significant new insights are emerging, i.e. when categories are well described and exhausted. This argument also underlines that a clear articulation of theoretical constructs is an essential part of any inductive research, hence it can be regarded as the departure point for the current research study to the empirical research.

For the current research purposes, the theoretical derivation of mitigation measures that are critical to Megaprojects (CMMs) represents the articulation of the theoretical constructs, as explained previously in Chapter 4 – Section 4.2. In this research, the derivation process of CMMs consists of two stages, as outlined in Figure 5.7, which is an expanded version of Figure 4.1. Stage 1 is discussed in details in Section 4.2.1, and it involves conducting a systematic literature review in order to identify a comprehensive list of recommended mitigation measures for Megaprojects based on the content analysis method and consists of three steps [100] as shown in Figure 5.7. Step 1 (preparation) involves selecting the unit of analysis and the research database. Step 2 (organising) involves coding and creating categories. Step 3 (reporting) involves reporting the analysis process results with sufficient details.

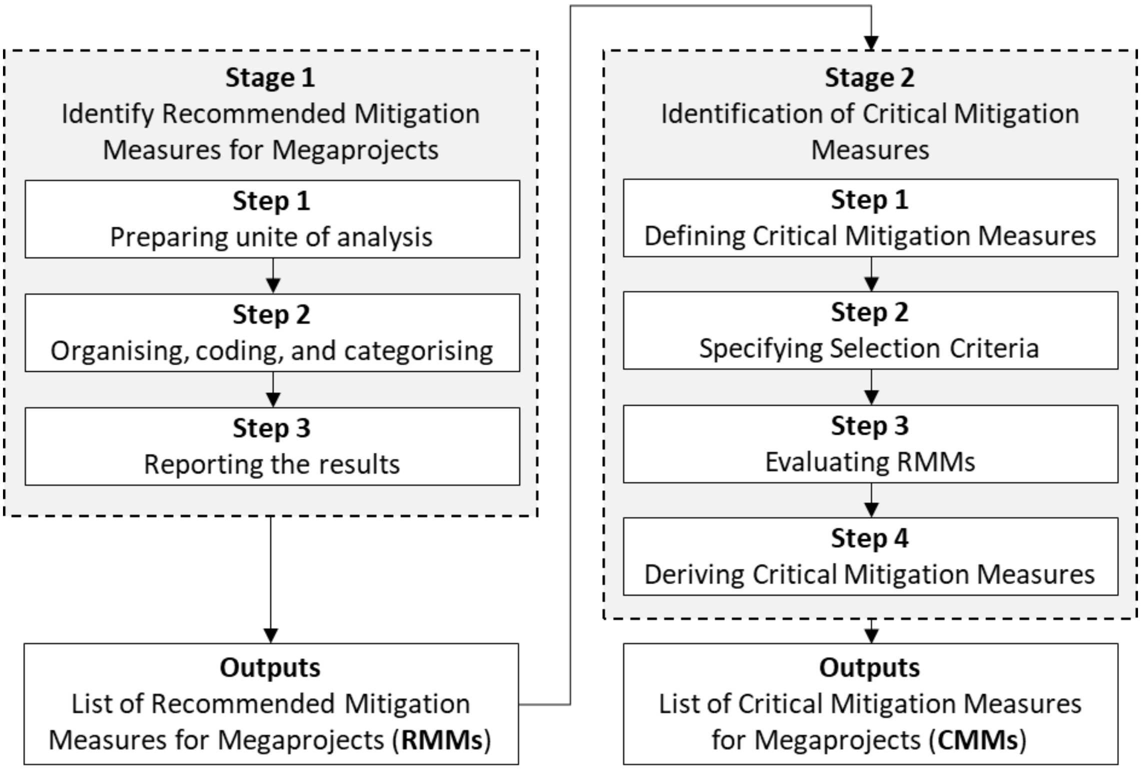

Figure 5-7 Theoretical Derivation of the Proposed Approach

In Step 1, Google Scholar search engine is used to identify relevant published materials on managing and mitigating risk in Megaprojects as (unit of analysis) by using three sets of keywords to retrieves data on Megaprojects, risk mitigation, and mitigation approaches, strategies, measures, methods, tools and actions. At the end of this step, hundreds of documents appeared in the search results. Therefore, in Step 2 (organising), the documents that appeared in the search results were read by the researcher through skimming and scanning technique in order to screen those relevant to manage and mitigate risks in Megaprojects. Thus, only 32 relevant documents then were carefully read in order to manually highlight any text that refers to actions lead to the management and/or mitigation of MRs and affect delivery performance. These highlighted texts were coded, and codes that contributed to the same meaning were then grouped under a single category. At the end of this stage, 10 unique categories were formulated as recommended mitigation measures for Megaprojects, which are then defined and described in details in Table 4.1.

Stage 2 is discussed in details in Section 4.2.2, and it involves conducting a qualitative process to derive CMMs from the comprehensive list of recommended mitigation measures for Megaprojects identified in Stage 1. Stage 2 consists of four steps, as shown in Figure 5.7. Step 1 involves defining what constitutes CMMs by classifying mitigation measures in Megaprojects. Step 2 involves specifying a set of selection criteria from the literature. Step 3 involves evaluating each recommended mitigation measure for Megaprojects against the set of selection criteria that distinguish between generic and non-generic mitigation measures. Step 4 involves deriving and selecting CMMs.

Step 1 is discussed in Section 4.2.2.1, and it involves defining what constitutes CMMs in order to use it as a benchmark to clearly identify and specify a set of selection criteria for evaluating the identified recommended mitigation measures in Stage 1. Step 2 focuses on specifying appropriate selection criteria against which the recommended mitigation measures for Megaprojects will be evaluated. For the current research purposes, a set of three selection criteria were considered to evaluate the comprehensive list of recommended mitigation measures, as discussed in Section 4.2.2.2. The selection criteria are applicability to reduce MCRs' probability and/or impact, practical reliability, and the ability to manage and/or mitigate multiple MCRs. Step 3 aims to evaluate the comprehensive list of recommended mitigation measures for Megaprojects against the selection criteria. To support Step 3, the literature was reviewed to collect relevant information about each recommended mitigation measure against each selection criterion, as discussed in Section 4.2.2.3. Step 4 aims to derive and select mitigation measures that are critical to Megaprojects (CMMs) from the evaluated list of recommended mitigation measures in order to theoretically form the proposed approach to risk management in Megaprojects as discussed in Section 4.2.2.2. For the current research purposes, the QCA is adopted in Step 4 to rationales two decisions. The first decision is to determine whether the recommended mitigation measures for Megaprojects meet the selection criteria presented in the previous step. The second decision is to determine whether the recommended mitigation measures for Megaprojects could contribute to the success of Megaprojects. Therefore, three success indicators reported by Locatelli *et al.* [268] – cost overrun, delayed in the planning phase, and delayed in the construction phase were used in the QCA to support the derivation process of CMMs. The outputs of Step 3 of Stage 2 is utilised to aid the first decision, whereas the literature review was conducted to collect relevant information to aid the second decision. At the end of Stage 2, four critical mitigation measures were identified for Megaprojects namely Act of Parliament (ACT), Project Management Office (PMO), Code of Practice (COP), and New Form of Contract (NFC).

5.7 Fieldwork Study

5.7.1 Structure of AGT Interview Questions

The AGT interview questions are structured into two levels, where level 1 involves fixed questions, and level 2 involves subsequent intensive questions, as shown in Figure 5.8. Fixed questions were asked to all experts (interviewees), at the beginning of each interview, to ensure that the interview followed the research problem and to ensure that the data collection process was consistent. These questions are general in nature and are open-ended; the experts were encouraged to talk about anything related to them. Further, they are more suitable for gathering information for the open coding, whereas the subsequent questions are more suitable for gathering information for the axial coding and selective coding. The fixed questions were sent in advance to the experts who agreed to participate in this research, to give them sufficient time to gather their thoughts about the topic under investigation.

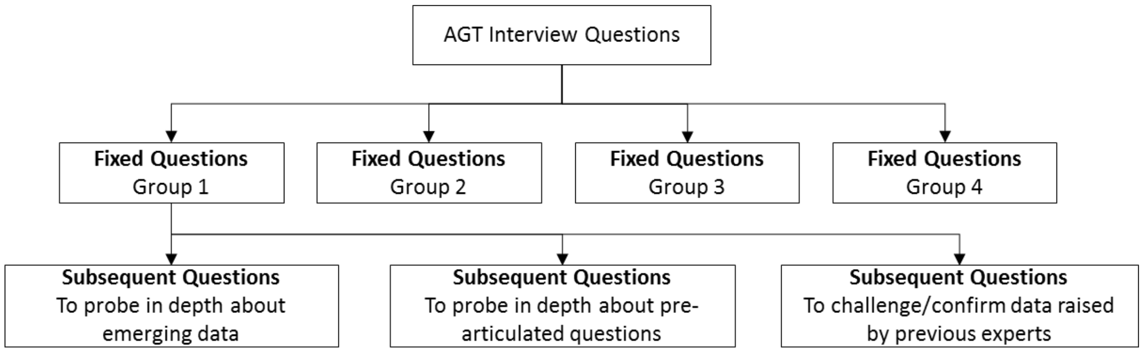

Figure 5-8 Structure of AGT Interview Questions

Once the fixed questions have been asked, three sets of subsequent intensive questions will be asked, which are influenced by each expert's answers during the interview as well as the implications of the theoretical sampling [469]. The aim of the first set of subsequent questions is devised on the spot for the purpose of further exploring the issues raised by the experts, which enables data collection to be driven by categories emerging from the field. Substantive information can be collected through in-depth probing of the experts' experience. How much further a specific topic should be explored relies largely on the interviewer's judgement of the importance and relevance of the issues to the research questions and the allowable timeframe.

The second set of subsequent questions is pre-designed based on the theoretical derivation of possible CMM proposals (ACT, PMO, COP and NFC) that are derived in Section 4.2 and defined in Section 4.4, which enables relevant data to be collected. Any issues that are implied from an expert's answers but not specifically mentioned by the expert are raised. This allows the identification of relationships between findings and existing literature. For the purpose of this research, the second set of subsequent questions involved questions encouraging the experts to reveal how to utilise the theoretical constructs of possible CMMs as tools to manage and mitigate MCRs. The third set of subsequent questions includes issues mentioned by experts in the previous interviews but not mentioned by the expert currently being interviewed. The purpose of these questions is to test and challenge the data explored from previous interviews, which in turn helps to verify and validate the explored data. These questions are also predesigned based on the theoretical sampling since the data is collected and analysed instantaneously once the interview is finished.

The subsequent questions also were asked during the interview when the researcher recognised that the interviewee's answers were not relevant or significant to the research study. The decision to ask these subsequent questions was supported by the researcher's general understanding of the MCRs and their possible CMMs. It should be noted that, on some occasions, some of the subsequent questions (sets 2 and 3) were sent in advance to the experts to answer specific questions and fill in some gaps.

5.7.2 Design of AGT Interview Questions

In this research study, MCRs and their possible CMMs are derived and defined from the literature systematically. Therefore, the theoretical derivation of possible CMMs to MCRs can guide the current research to design, frame and structure the questions needed for the data collection phase during the fieldwork study phase. Therefore, in this study, the AGT interview questions are designed based upon the theoretical constructs of possible CMM proposals (ACT, PMO, COP and NFC) that are derived in Section 4.2 and defined in Section 4.4 to manage and mitigate MCRs. Accordingly, four groups of questions are designed, where each group involves two types of questions (fixed and subsequent), as discussed in the previous Section 5.7.1. The four groups of question are presented in Appendix E. The purpose of the first group of questions was to seek the experts' views and thoughts about the viability of legislating and enabling a specific Act of Parliament for Megaprojects (ACT) to manage and mitigate MCRs. The purpose of the second group was to seek their views and thoughts about the viability of launching a Project Management Office (PMO) at the national level in the UK to manage and mitigate MCRs. The purpose of the third group of questions was to seek the experts' views and thoughts about the viability of developing and mandating a specific Code of Practice (COP) to manage and mitigate MCRs. The purpose of the fourth group was to seek their views and thoughts about the viability of developing a New Form of Contract (NFC) for Megaprojects to manage and mitigate MCRs.

Although each group of questions is designed to address a particular issue, they have shared purposes. The four groups of questions are designed to help the researcher during the interviews to stimulate the expert interviewees by seeking their views to test and/or challenge the structure and operation of CMMs. They also help to probe the perceptions, attitudes and experiences of the interviewees relating to how the suggested CMMs can be used to manage and mitigate MCRs collectively. This includes extracting information about what could be done differently to manage and mitigate MCRs to improve Megaproject performance, and also includes whether the suggested CMMs could reduce the impact and/or probability of MCRs. It further includes extracting information on whether the suggested CMMs could provide better information about risk allocation.

5.7.3 Coding Procedure and Data Analysis

Qualitative data analysis is defined as the process of bringing order, structure and interpretation to the mass of collected data [423]. Theoretical coding is the primary tool for data analysis in Grounded Theory research [424]. It helps the researcher to fracture the data and rearrange it into categories, which then facilitates the comparison of data within and between these categories [469]. The current research study follows the coding approach proposed by Corbin and Strauss [425] as the most common approach, which consists of three types of coding: open coding, axial coding and selective coding, as shown in Figure 5.9.

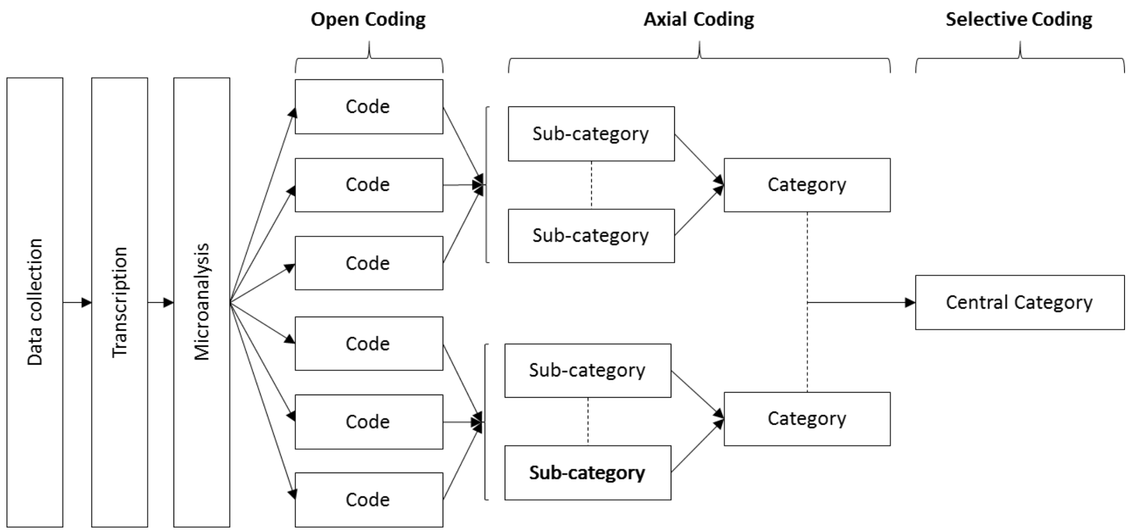

Figure 5-9 The Process of Developing Central Categories

To use this coding system, data collected from the interviews were analysed immediately to allow theoretical sampling [470]. Once an interview was completed, the researcher (interviewer) listened to the recording of it straightaway, or read the interview notes (for those without recording permission). This is an essential action because the researcher is still able to remember the expert's tone and attitude. The recorded interview was then transcribed to represent the dynamic nature of the conversation [471]. The transcriptions were read carefully to obtain a general sense of the information and reflect on that data's overall meaning, and they are provided for all phases of the questions, as listed in Appendix F. Further, a clear indication of the questions asked to all experts is also provided in Appendix G.

The transcription of each interview was analysed through a microanalysis process [472], which consists of steps including a detailed line-by-line analysis, labelling, categorising and identifying relationships. Due to the small interview sample, a simple manual coding technique was used for the microanalysis process, which may be sufficient for this purpose [185]. Therefore, highlighter pens and markers were used in order to code the data manually. This allowed the researcher to intellectually communicate and connect with the data to facilitate the comprehension of the emerging phenomena and to generate the relevant theory [426]. The microanalysis process was facilitated by using NVivo 11 software, which helped the researcher to organise, manage and store the collected data.

During the microanalysis process, the major points, along with a short profile of the expert, were marked down for each transcript in order to understand the interview trends and rationalise the research findings. Then, the important data was highlighted for each transcript to identify key incidents. The identified incidents were labelled and coded by segmenting the data by making sense of individual fragments of information. Memos were also written down to reflect the researcher's understanding and interpretation of the data [473]. Accordingly, various conceptual labels (codes) were constructed to reflect the researcher's interpretations and inform the subsequent concepts [473].

These codes were identified by constantly comparing and contrasting them with those already identified in order to establish relationships [469]. This coding process includes comparing incident to incident, incident to code, code to code, code to the concept, and concept to concept. The identified codes were developed into a set of sub-categories through open coding phase, and the relationships of these sub-categories were established and developed into categories through axial coding. Then the developed categories were integrated into a central category through selective coding, which collectively and empirically form and generate the proposed approach of the current study [425]. Each central category was developed fully in terms of its properties and dimensions. As more incidents and categories emerged, they were further labelled under broader categories.

Therefore, the identified incidents, codes, categories, and their relationships were then utilised to design questions for the following interviews to validate or contradict the findings. This stage of analysis helped the researcher to determine the theoretical sampling to orientate the selection of the experts for the subsequent interviews [469]. The theoretical sampling was determined to identify experts suitable to address gaps in a particular category and to provide some rationales to fill them.

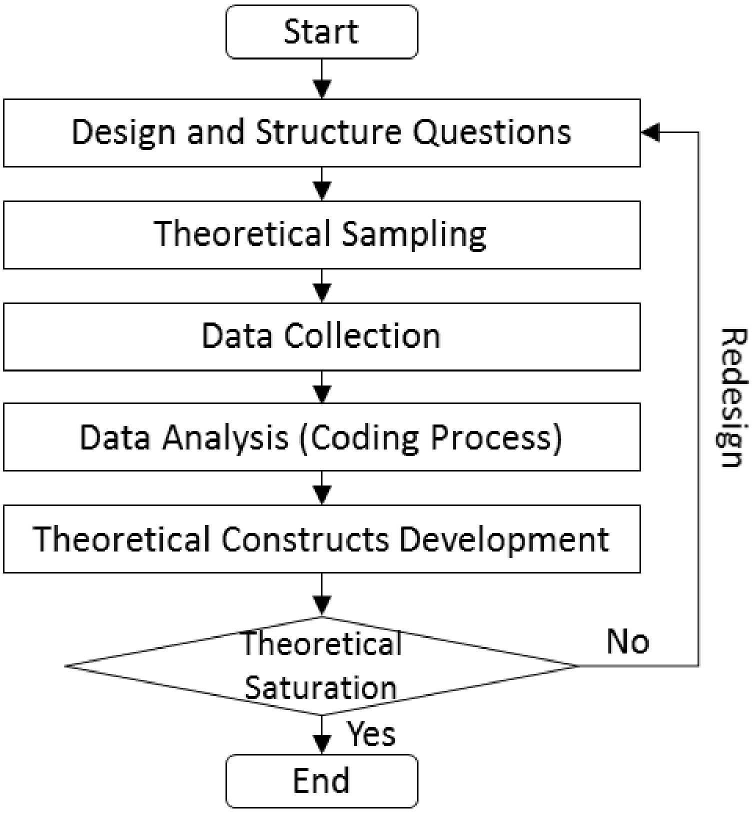

Figure 5-10 Theoretical Saturation Process

This constant comparison continued until the theoretical saturation was reached, which is the point at which all categories are well developed, and further data collection and analysis add no new conceptualisation [469, 471]. In this research, the theoretical saturation was reached when the three conditions of theoretical saturation set by Corbin and Strauss [425] were satisfied. These are: the collected data reveals that no new or relevant information seems to be emerging regarding a particular category; the category is well developed in terms of its properties and dimensions, demonstrating variation; and the relationships among categories are well established and validated [425]. Accordingly, if the theoretical saturation point was not reached then the researcher (analyst) could modify and reframe the questions and/or determine the theoretical sampling to orientate the selection of the experts for the subsequent interviews, as shown in Figure 5.10. The main categories that emerged from the analysis of the grounded data gathered from the two stages are Act of Parliament (ACT), Project Management Office (PMO), Code of Practice (COP) and New Form of Contract (NFC).

5.7.4 Selection of Experts (Interviewees)

The choice of participants and their appropriateness is fundamentally important for qualitative interviews using grounded theory simply because participants are expected to provide in-depth information rather than simple yes/no answers [471]. Therefore, it is important to ensure that the participants are properly and carefully selected based on their ability to make a sound contribution and help illuminate details concerning the topic being explored [423]. In this research, high-quality data needs to be collected on how to manage and/or mitigate MCRs collectively using the pre-determined theoretical constructs of possible CMMs (ACT, PMO, COP and NFC). This kind of data can be obtained from practitioners (experts) who are actually involved in delivering Megaprojects and who are thoroughly familiar with aspects of risk management. Such experts can share their experience to reflect the realities of engineering with a deep understanding of what could be applied for Megaprojects and what could not. Therefore, for the current research, the experts were carefully selected by examining their extensive experience, knowledge and professional standing in planning and delivering Megaprojects over a period of time (20 years plus). These experts who had/have major risk responsibilities in Megaprojects are more capable of answering questions and providing in-depth information on managing and mitigating MCRs in a better way. This is because managing and mitigating risks essentially rely on the knowledge, judgement, perception and experience of people involved in the project [93, 97, 102, 165]. Accordingly, a process is proposed to identify and select Megaproject experts for data collection, as shown in Figure 5.11.

Although there are neither minimum sample size requirements nor statistical drivers motivating researchers to sample a predetermined number of experts in AGT [469], the sampling must begin purposively [470]. Some authors argued that sampling in grounded theory is thus sequential, beginning with selective sampling and moving into theoretical sampling when concepts begin to emerge [474]. Therefore, in the current research, the interviews started with a predetermined sample of experts, who were identified and selected from the researcher's professional network, as shown in Figure 5.11. These experts include but are not limited to programme directors, technical directors, risk managers, chief executives, heads of planning and chief operations officer. The research process then involved employing theoretical sampling to identify and select specific experts. Theoretical sampling directs the researcher to identify and select experts on the basis of their potential contribution to the development and testing of theoretical constructs that have emerged in the data [468]. Additionally, snowball sampling was used to identify and select experts, where the previously mentioned experts were asked to nominate and recommend names of other experts who could potentially contribute to filling gaps in the theoretical constructs.

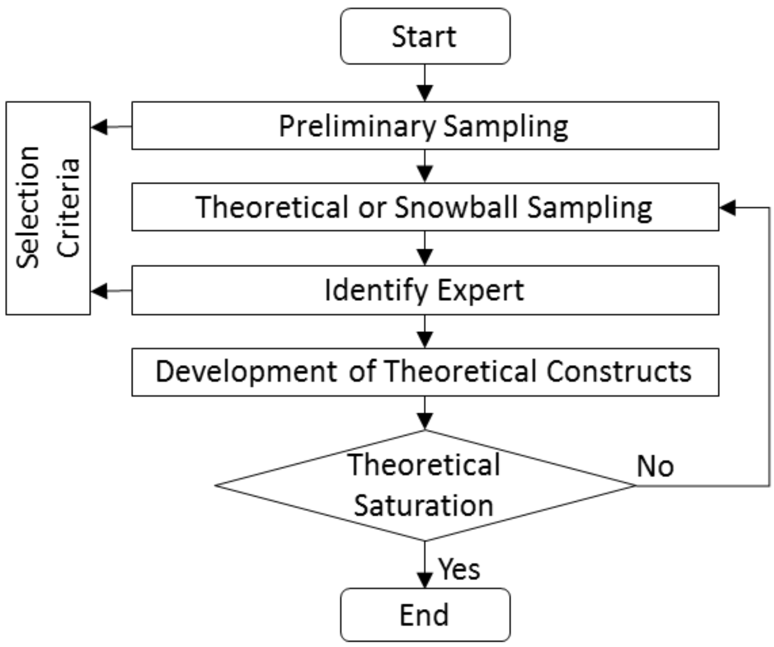

Figure 5-11 Process to Select Experts

Although researchers must decide when to shift from selective to theoretical sampling [474], this decision is controlled by the implications of theoretical saturation when new data that is examined provides no new information in terms of refining the category or its properties, or its relationship to other categories [426]. Based on the above process, 28 established and widely recognised experts in Megaprojects at different organisational levels and from different organisations were interviewed. Their profiles are provided in Appendix H. Most of the experts have extensive experience and expertise in planning and delivering Megaprojects in the UK and other countries. Although the scope of the research is focusing on Megaprojects in the UK, some of the experts who were approached and recruited are from different countries and regions outside the UK. For example, six experts come from the USA, and two experts are from Australia, and one expert is from Canada. This geographical diversity of expertise is essential as Megaprojects are global phenomena, where international experts who have good experience and expertise in Megaprojects can contribute to this research. Furthermore, this geographic diversity is influenced by the snowball sampling and target sampling basis.

5.7.5 Data Collection Protocol and Ethical Considerations

Before commencing the research interviews, the researcher had applied for formal ethical approval from the Ethics Committee of the University of Leeds (Appendix I). Once the ethical approval was obtained, the process of identifying, approaching and recruiting Megaproject experts (interviewees) was influenced by a set of selection criteria (Section 5.7.4) such as their professional expertise and work experience in Megaprojects, as shown in Figure 5.12. Accordingly, any expert that did not meet the selection criteria was excluded from the interviews.

Once the potential experts were identified, a formal invitation letter to take part in the research (Appendix J) was sent to them via email. This letter was supported by a participant information sheet (Appendix K) that gave them an idea about the nature of the current research and its implications. A consent form (Appendix L) was also attached to the invitation email to confirm the participation status of the experts by giving them opportunities to ask questions about the research before returning the consent form. Any expert who did not accept the invitation or did not respond to the invitation email within 14 days was excluded from the interviews.

Once the experts had agreed to be interviewed, arrangements were made between them and the researcher about when and where the interview would take place. The experts were informed that the interview would be face-to-face/Skype/phone call at their convenience and would take 45-60 minutes. At the start of each interview session, the researcher thanked the expert for his/her participation. This was followed by a short statement about the voluntary nature of the participation and the expert's right to withdraw at any time without giving reasons, and at no penalty. The experts were asked to provide their permission for the interview to be recorded for the current research project purposes. For anonymity purposes, the experts were also informed not to reveal their full names when the audio/video recorder was turned on.

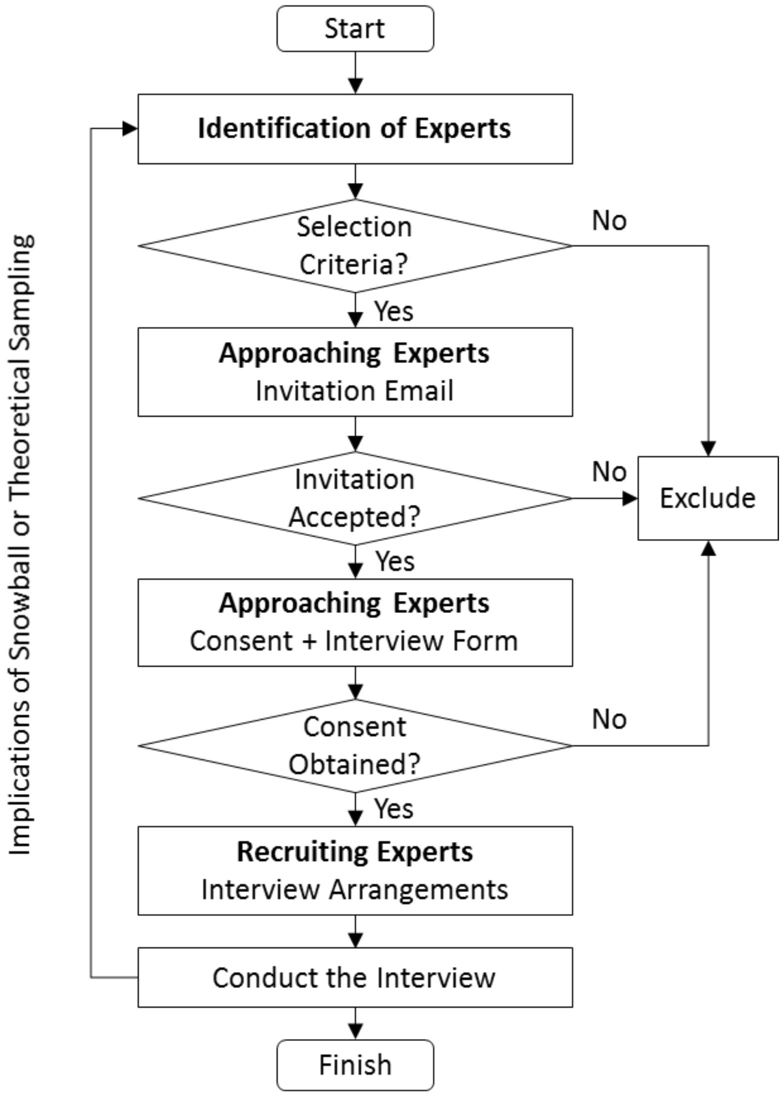

Figure 5-12 Data Collection Protocol

Once the experts were happy to proceed with the interview, they were given a brief introduction to the research in order to warm-up the interview. The brief introduction started with the definition of Megaprojects and how these are different from conventional projects. It also included the current situation of Megaproject performance and its poor records. This was followed by how the 'scaling-up' of conventional approaches to managing Megaprojects is not delivering improvement. The aim of the research was also provided. The main purpose of this brief introduction is to ensure that the problem statement is fully understood and to avoid any misunderstanding. Moreover, it will motivate the experts to comment about the research rationales.

Once the brief introduction was finished, the experts were asked to talk about their experience in Megaprojects, and whether they recognised the definition of Megaprojects. This will help the researcher ensure that the experts have the knowledge and experience in Megaprojects to provide reasonable data and information. Moreover, it will help direct the experts to answer questions more related to their experience to avoid wasting time. Accordingly, and based on the area of expertise, the general research question (Appendix E) will be asked and/or modified.

Once the data was gathered, the experts were then thanked for their participation and their information. At this stage of the interview, the experts were asked if it would be permissible to contact them again later to fill in any gaps and to obtain their views on the final outcome of the research. Each expert was asked during the interview to nominate one or two individuals in his/her network who could contribute to the research. This was so that a snowball sampling technique could also be used to identify potential experts.

The interview times ranged from 30 to 180 minutes accordingly. The majority of interviews were undertaken through Skype, while five interviews took place over the telephone, and only one interview was face-to-face. Most of the interviews were conducted using the researcher's personal laptop inside the School of Civil Engineering at the University of Leeds. There is also a meeting room equipped with a big screen and PC that facilitated the Skype interviews. All the experts were asked for their permission to record the interview, and all confirmed that this was acceptable.

5.8 Research Validation

For any research study, it is important that validity can be demonstrated as this is a concept that allows an audience to be convinced that the research questions have been answered using appropriate methods. External validity is defined as the extent to which the findings from a particular research study are generalisable to all relevant contexts [185]. It aims to address the crucial process of validation of the developed approach in order to ascertain the logical soundness, completeness, accuracy, acceptability, practicality and effectiveness [185, 413, 423]. For the current research purposes, the objective of validation is to assess the performance, functionality and practicality of the proposed approach in order to ensure its practical applicability in solving real problems. A valid approach would be one that has proven to be effective in performing the tasks for which it was designed.

Although there are several methods that can be used to validate project management research, the most common are case study, interview survey, and Delphi technique [413, 416, 417, 475]. Because Megaprojects are unique by definition, it is difficult to select case studies that can represent all Megaprojects; thus, the case study is not considered. Interviews can provide in-depth and high-quality data to verify and validate the proposed approach. However, it is difficult to reach agreement among participants; therefore, this method is not considered. The questionnaire method lacks consistency when it comes to the validation of the whole system; hence, it is also not used. In this research, the Delphi technique process is adopted as the most appropriate method to validate the tested MCR mitigation measures proposals (ACT, PMO, COP and NFC), which collectively constitute the new approach to risk management in Megaprojects.

The key rationale behind using the Delphi technique in the current research study is based on the need to effectively engage with a range of Megaproject experts from different geographical and organisational background to seek their views and thoughts on the design structure of the proposed approach. Most importantly, it is to achieve a high degree of agreement (consensus) between these experts on the implication of their views on the proposed approach in a short period of time. Such consensus is essential to validate and generalise the proposed approach to enable Megaproject practitioners to identify, manage and mitigate MCRs for all Megaprojects and only for Megaprojects. According to these justifications, the Delphi technique is applied in this research, and both the adopted Delphi validation process and Delphi results are provided in Chapter 6.

5.9 Summary

This chapter has presented and discussed the adopted research methodologies supported the main philosophical views and rationales behind them. It has presented and justified the use of inductive reasoning for this research study. It has also justified that qualitative research is the most suitable approach to address the research question and hence achieve the research aim and objectives. Then the chapter has introduced and justified the use of AGT as the most appropriate research method to address complex phenomena like Megaprojects. The chapter has described in detail the AGT procedure adopted to collect and analyse the data by providing a detailed discussion about the design and structure of the semi-structured interview questions as well as the adopted coding procedure. The chapter finally presented and justified the use of the Delphi technique as the most suitable method to test and validate the research findings in the real world.

Chapter 6 Research Findings

6.1 Introduction

This chapter presents the findings from empirical research. These findings have been collected from well-established and recognised experienced Megaproject experts at the very senior level and different organisational levels. The chapter is structured based on the emergent themes and has seven sections, including this introduction. Section 6.2 briefly discusses the process, which led to the derivation of the emergent themes. Sections 6.3 – 6.6 present the key empirical findings of the emergent themes supported with quotation examples. Lastly, Section 6.7 summarises the chapter.

6.2 Emergent Themes from AGT Interviews

The current research study uses the AGT method to collect data from Megaproject experts through semi-structured interviews as justified in Section 5.7. These interviews aim to explore the views and thoughts of Megaproject experts towards improving risk management in Megaprojects through the proposed approach in Chapter 4. Therefore, the interview questions are structured and designed based on the theoretical constructs of the proposed approach namely (ACT, PMO, COP, and NFC). The data generated from the interviews were coded and analysed using the coding procedure proposed by Corbin and Strauss [425]. This coding procedure involves three steps – open coding, axial coding and selective coding, as discussed and explained in Section 5.7.3. Following this coding procedure analysis, the theoretical constructs of the proposed approach were empirically grounded in the qualitative data to generate emergent themes and categories. Overall, the coding process has produced a 'tree of information' which shows the relationship between the emerged codes, sub-categories, categories and central categories, as shown in Table 6.1.

During the microanalysis process, hundreds of incidents were identified from all the transcripts, which were coded into 57 codes based on the researcher's interpretation of the emerging concepts as listed in Table 6.1 [468]. For example, the code "compensations" was applied to any text in the transcriptions that was associated with the compensation events, actions, or measures or some similar variant. Codes that belong to the same theme were developed further into a set of sub-categories through the open coding phase. The relationships of sub-categories were then combined into 12 categories, which were established and developed through axial coding, as listed in Table 6.1. For example, three codes, “dynamic life cycle of Megaprojects”, “unforeseen technologies” and “industrial contribution to Megaprojects”, were combined and integrated under a single category, “updating best practices”. The rationale behind combining these three codes is that they represent different risk sources that could lead to the occurrence of a Megaproject lacking adaptability to best practices. The developed categories were assembled and integrated into four major themes (central categories) through the selective coding step, as listed in Table 6.1. For example, three categories, “benchmarking best practices”, “compliance with best practices” and “updating best practices”, were integrated and interpreted into a central category “COP”. The rationale behind this interpretation is that the three categories essentially shed light on the standardising of best practices and processes in Megaprojects. Logically, the emergent data (codes and categories) of this central category “COP” are solely linked to the theoretical construct “COP” of the proposed approach. Therefore, this theoretical construct “COP” will be shaped based on the understanding and interpretation of the associated empirical research findings. Thus, and by following the above coding process, the four emergent themes (central categories) – ACT, PMO, COP, and NFC – collectively will help the empirical development of the proposed approach to risk management in Megaprojects. The following sections present the emergent four themes in further detail, and individual quotations are included to provide supporting verbal evidence.

Table 6-1 Emergent Themes from AGT Interviews

Open Coding	**Axial Coding**	**Selective Coding**
Codes	Categories	Central Category
• Statutory Protection Mechanism • Statutory Provisions • Parliamentary Involvement • Actions from High Authorities • Stabilising Delivery Environment	Statutory Instruments	**ACT**

Open Coding	Axial Coding	Selective Coding
Codes	Categories	Central Category
• Legislative Mitigation Measures • Compensations • Rights of Private Sector • Suspending Compliance with Legislations • Governmental Guarantees • Public Consultation	Legislative Exemption Mechanism	
• Adaptability of Megaprojects • Change in Legislations • Change in Policies • Change in Regulations • External and Political Risks	Mitigating Non-Commercial risks	
• Inconsistent Governing • Lack of Resources and Expertise • Lack of Project Leadership • Lack of Decision-Making Process • Project Management Capabilities	Rigorous Governance Structure	**PMO**
• Lack of Compliance with Standards • Public Sector Organisation • Centralised PMO • Institutionalise Organisational Processes and Methodologies • Coordinate and Monitor the Delivery Process	Strategic Oversight	
• Lack of Stakeholder Alignment • Complex Relationship Among Parties • Lack of Communication • Megaproject Facilitator • Unforeseen Stakeholder Requirements • Influential Level of Stakeholders • Articulating and Communicating Strategic Objectives between Organisation Levels	Aligning Stakeholders	
• Standardising and Codifying Best Practises • The Lack of Shared Practices • Differences between Megaprojects and Conventional Projects • Scaling-Up Best Practices	Benchmarking Best Practices	**COP**
• Mandating Best Practises • Poor Compliance with Guidelines and Standards • Poor Management	Compliance with Best Practices	
• Dynamic Life Cycle of Megaprojects • Unforeseen Technologies • Industrial Contribution to Megaprojects	Updating Best Practices	
• Contractual Provisions and Mechanisms • Appropriate Risk Allocation • Complex Procurement Process • Modifying Existing Contract Systems	Contractual Measures	**NFC**
• High Risks and Uncertainties	Incomplete Contract	

Open Coding	Axial Coding	Selective Coding
Codes	Categories	Central Category
• Inadequate Contingencies • Incomplete Design • Unforeseen Technologies • Disputes between Stakeholders and Parties		
• Turbulent Delivery Environment • Frequent Changes in Megaprojects • The Interface between Project Packages • Client Restrictions and Requirements • Combining Different Forms of Contracts	Flexibility	

6.3 Act of Parliament (ACT)

The findings confirm that there is no specific Act of Parliament (ACT) for Megaprojects in the UK. The findings reveal that legislating and enabling such an ACT as a measure could drive improvements in the delivery of Megaprojects by establishing a clear institutional framework specifically for appraising, planning, procuring, governing, and implementing Megaprojects [E2, E3, E4, E5, E7, E11, E18, E27]. Accordingly, the findings indicate that enacting and enabling such an ACT will help in providing a clear legal framework that would stabilise the delivery environment of Megaprojects. For example, one expert stated that:

> *"All Megaprojects will to a great or less extent be influenced by governments, and governments, in particular, civil servants, have the tendency to keep options open in terms of policies and regulation, so yes I think it will be worthwhile to have such Act of Parliament to stabilise the delivery environments of Megaprojects". E8*

The findings also show that enacting such an ACT could provide protections against non-commercial risks and actions that could be located beyond the project's boundary in matters concerning changes in legislation, changes in laws, changes in regulations, corruption, expropriation and nationalisation, and incomplete contract [E2, E3, E4, E5, E7, E11]. The findings show that, primarily, the ACT could increase the adaptability of Megaprojects to the unforeseen changes in legislation, policies, laws, and regulations [E1, E2, E6, E10, E11].

Some experts argued that enabling such a mechanism could help in managing and mitigating the risk of corruption [E2, E3, E4, E7]. One of the experts stated:

> *"I subsect if we had such ACT, legislative changes would possibly be alleviated … I will give an analogy ... when I started my position in this oil and gas Megaproject, there was no consideration of global warming ... all environmental impact was around oil spill, which has been taking seriously…so in oil exportation you don't worry about carbon footprint, which is now in many parts of the world consider it as a big issue because I think that relies on society who decided that we don't want global warming ... such Act of Parliament would make the government aware of such trends and protect the clients of Megaprojects from its implications". E3*

The findings show that the ACT needs to include two main issues: an exemption and compensation for managing and mitigating the risk of lack of adaptability to legislations and policies change in a better way. [E5, E6, E7, E8, E9, E10]. For example, two experts stated the following statements:

> *"I think such Act of Parliament needs to have clauses that make it clear that some protection needs to be provided by high authorities to exempt Megaprojects from the implications of unexpected changes in legalisations and/or policies". E5*

> *"I suggest the Act of Parliament needs to have measures in place which can be used to compensate private party and commissioners of Megaprojects for additional costs/and expenditures imposed as a result of legislation changes by the governments". E7*

The findings suggest that the ACT can provide compensations in the event of changes in legislation or regulations specifically applicable to a Megaproject's assets or the services it provides during the implementation and operation phases [E7, E8, E9, E10, E11]. For example, one expert stated:

> *"The Act of Parliament as I suppose can expressly establish the right of compensation for uncertainties in-laws, policy, and*

> *regulation which arise over during the delivery of Megaprojects". E8*

The findings confirm that compensation is very often not adequate to satisfy the expectations of those who are impacted by legislation changes [E7, E8, E9, E10]. Responding to this point, the findings show that the ACT should provide a practical procedure to obtain a governmental guarantee for extending the concession period and milestone dates of the project as a compensation measure [E9, E10]. For example, one expert stated:

> *"I would suggest that the Act of Parliament should clearly state that any delaying effects on the project schedule and/or cost escalation resulted from changes in governments need to be compensated by extending the construction period, the concession period, or both". E10*

The findings show that extending the concession period is a more suitable method of compensating Megaprojects than using direct subsidies for complying with legislation associated with a significant impact on the public and environment such as health and safety [E9, E10, E11].

The findings show that the ACT could establish a mechanism that would certify and insulate Megaprojects from potential changes in laws, policies, and regulations [E4, E5, E7]. This mechanism aims to increase the adaptability of Megaprojects to legalisation changes and similar external actions, and the findings suggest establishing legislative changes exemption mechanism within the ACT [E4, E11, E15].

Experts were asked about the key functions of such a mechanism, and most of them were of the view that the mechanism could provide guarantees that any changes in laws, policies, or regulations are beyond the scope of Megaproject contracts [E4, E10, E11, E13, E14, E15]. There were some suggestions that the mechanism can also allow for suspending compliance with changes in laws, policies, and regulations for a defined period to reduce the turbulence that could result from instant compliance [E6, E7].

The experts suggest that it is also possible under such a mechanism to insulate Megaprojects from external actions such as expropriation and/or nationalisation

[E5, E11]. Other experts argued that such external actions need to be defined clearly and precisely in advance [E6, E7]. For example, one expert stated:

> *"It is possible to pass a law under the exiting Conservative parliament to say that HS2 and any private funding assets will be insulated from any loss over a certain period due to the expropriation or nationalisation". E6*

The findings also show that the mechanism needs to assess and quantify the impact that changes in laws, policies, and regulations could have on existing and future Megaprojects [E8, E12, E13, E14, E15]. Therefore, the findings suggest that the mechanism may require a sophisticated cost/benefit analysis to take into consideration the impact of global and external events outside the scope of the projects [E8, E11, E14, E15].

The findings also show that the mechanism should consider a threshold to exclude Megaprojects from legislative changes by taking into consideration the size, complexity, and duration [E7, E11, E14, E15]. For example, if there is a £1 billion industrial project with an 18-month duration, then the risk in terms of legal and regulatory changes is very small, but if there is a multibillion-pound refinery project scheduled to take four years, the risk is more significant. Moreover, if there is a public infrastructure project scheduled for over ten years, the risk is much higher. Therefore, the time duration is the number one factor concerning this mechanism and a precondition, if you will, would be around scale and complexity [E7].

The findings also show that the mechanism could exempt Megaprojects during the implementation and/or operation phases from changes in policies, laws, and regulations for a defined period of time [E12, E14]. Accordingly, the findings show that the mechanism has to be implemented after the sanction decision [E12, E14, E16].

Most of the experts indicate that these actions as measures need to be located within the sponsor organisation at the corporate level [E13, E14, E16, E17]. One expert justified this by stating that:

> *"I think the government should give full responsibility for political and legal risks … if the government and high authorities take these*

risk seriously, I think the delivery performance of Megaprojects will improve … but unfortunately, governments were too busy dealing with other stuff". E21

The experts suggest that the exemption conditions could be set by high commissioning authorities (mechanism commissioner). [E17. E18, E19, E20, E21]. One expert stated:

> *"The commissioner of this mechanism should be able to assess the impact of the change of local laws … you could do a cost-benefit analysis to the project from a change of law". E20*

A recurrent theme in the interviews was a sense amongst experts that the ACT would be associated with several challenges and difficulties when it came to the practical implementation [E20, E23, E24, E25, E26]. For example, one of the challenges that could arise during the process of enabling such an ACT is that once in place, it will be difficult to change, and it may also be too vague to be correctly interpreted [E20, E22]. Some experts have also expressed concerns about the lengthy period, perhaps many years, required to legislate and enable such an ACT [E25, E26, E27, E28].

Few concerns were expressed regarding whether enabling such an ACT is most suitable for developed countries like the UK or less-developed countries (LDCs) [E21, E26, E28]. One of the experts stated that

> *"The protection against changes in-laws can be provided by the sanctity of contract, which means that the Law Courts (being independent of the government in a developed country like the UK) will uphold the contract against the government, if necessary". E21*

Some of the experts argued that the exemption mechanism could be applied too liberally in a way that could reduce the sovereignty of the host country [E21, E22, E24, E26]. One of the experts justified this by arguing:

> *"I would be very careful in having such an authority examine Megaprojects from national or local law based on their interest, because of the issues of sovereignty". E24*

Another expert suggests that the UK Parliament could also determine a threshold that no more than 15 Megaprojects may be exempted over the next ten years as an example [E20]. Some of the experts claim that it is not feasible to exempt Megaprojects from changes in national laws using such a mechanism; instead, it could be applicable to the context of local laws (Byelaws) and regulations [E22, E24, E25, E26]. For example, one interviewee said:

> *"The national law cannot be restricted by such a mechanism, whereas the local law could be… I suspect the national law takes precedence over the local laws, and I think the national law put a restriction on the local law concerning these very special projects". E22*

6.4 Project Management Office (PMO)

The findings strongly confirm that Megaprojects commonly lack the right capabilities and skills, especially in the public sector organisations at the national level [E1, E2, E3, E4, E5, E6, E7, E8]. As one expert put it:

> *"In my experience, typically, people who are making Megaprojects tend to make assumptions that everybody who has done large projects could do major Programmes or Megaprojects, and that is not true. Instead, it needs to be very careful when it comes to selecting people to do Megaprojects and similar programmes, as they need to understand what they are doing and to be realistic and have had significant experience and expertise in all sorts of projects, because otherwise they will be optimistic and they will not be able to solve and handle major risks". E5*

The findings suggest the need to establish a central authority to specify experience and expertise requirements required for Megaprojects [E1, E3, E4, E5, E12, E16]. Experts alluded to the notion of establishing a Project Management Office (PMO) at the national level by stating:

> *"I strongly believe that there is a need for a pool of resources of expertise and experience at the national level to deliver this sort of projects". E3*

This suggestion has been confirmed by the majority of experts, who emphasise that the setting-up of a PMO is a fundamental measure that is required for facilitating the delivery of Megaprojects [E9, E10, E12, E14, E16, E17, E18]. For example, experts stated:

> *"I see your point … and that is why in my opinion having a group like a centralised PMO who could establish and implements best practices and maintains standards related to Megaprojects is very important". E12*

> *"Sometimes the UK creates a statutory PMO called a Development Zone, Development Agency or Development Authority … Doing this requires an Act of Parliament … This development zone/agency/authority will have a budget to invest as well as special project development and planning powers. This model has been very successful. It is an interesting question as to why this model is not used more often in the UK, as it clearly works well? … I think the idea of a "national PMO" is very different". E16*

Experts were asked to indicate and explain which MCRs could be managed and/or mitigated by the PMO. The findings show that the role of the PMO as the main facilitator and coordinator of the project can help all stakeholders to identify, articulate, and communicate their needs as (strategic objectives) clearly [E2, E3, E4, E5, E6, E10]. This is justified by one expert who stated that:

> *"Managing politicians and expectations is probably almost the most important thing the PMO can do in the first year of a Megaproject". E5*

Another expert stated that:

> *"In my opinion, the PMO does not have to take sides, and it is only interested in getting the programme done… so it is neither owner nor contractor, so it can facilitate the discussion by bringing together all of the stakeholders, so they all get to talk to each other, and the PMO can create an environment of problem-solving rather than a finger-pointing environment". E6*

> *"I think aligning stakeholder expectations is one of the major risks that could be handled by this PMO since it can provide as a coordinator better directions towards the engagement of stakeholders from the outset". E10*

The findings show that the PMO is the most appropriate party that could also help to manage scaling-up issues of Megaprojects from the outset since it covers almost everything including risks, finance, stakeholders, and roles and responsibilities [E2, E5, E8, E9, E10]. One of the experts stated that:

> *"For example, in our project, as the PMO office we created a programme management group at different six programme management contractors, and we put a structure in place so we could scale-up everything we want to do". E8*

The findings also show that a PMO can help in managing the operability by facilitating the engagement of a senior operator team from the outset [E8, E10]. One expert stated that:

> *"As a PMO, what we did in our project, we got the operator involved from the beginning to build our documentation on the maintenance platform, so when we got done with construction it automatically turned over to the operator… this was because the operators were involved when we were doing everything from the outset, so the operator team had complete information about everything such as equipment, training required, and parts list etc.". E8*

Experts were asked to suggest the main activities they would expect to be handled by the PMO to manage Megaprojects in a better way. The findings show that one of the main function of the PMO is to institutionalise organisational processes and methodologies for Megaprojects in the UK [E6, E7, E8, E9, E11]. For example, one expert stated:

> *"I think the PMO will help us to improve the delivery of Megaprojects by institutionalising organisational processes and methodologies". E6*

Other experts suggest that the main function of the PMO would be achieving the organisation's financial and strategic goals [E7, E10, E12]. For example, one expert stated:

> *"I think that the main role of the PMO would be to provide a strategic oversight by planning, to coordinate and monitor the delivery process of Megaprojects, this eventually could help to achieve the organisation's financial and strategic goals". E7*

Other experts suggest that the PMO could help the decision-makers to make better decisions [E6, E7, E8, E11, E12]. For example, one expert stated that:

> *"The value of PMO when you have a competent people, so they can help guide the decision-maker in making the right kind of decisions about both get it they do". E8*

A common view among the experts was the main role of the PMO would be to provide a strategic oversight by planning, coordinating, and monitoring the delivery process of Megaprojects [E10, E12, E13, E16, E17, E18]. Therefore, the PMO will be the central source of information that can provide Megaproject clients with the resource and capabilities support. For example, one expert stated:

> *"The role of the PMO is like the leader of the band, so you work with all people who are involved because they all have a different view of what has been done, so bringing them together, so everybody understands all the roles and responsibilities of all the entire team. Everybody clear from the beginning who does what". E12*

The findings suggest that the PMO has to be supplied with data from Megaprojects at the lowest level to monitor the progress and to make decisions. E12, E13, E16]. For example, one expert stated:

> *"The PMO is going to monitor project and programme … therefore the information they need has to be supplied … for example, if the PMO wants to measure the earn value formation of all project and programs, in the draft framework has to say, suppliers must provide and report back earn value information". E13*

The findings also show that PMO would report information and progress reports to the relevant government agencies and update the sponsor about the progress to aid their decisions [E10, E11, E12].

The experts suggest that in order in ensuring that the best practices are followed by Megaprojects over the whole life cycle, a specific COP could be developed and mandated by the PMO [E10, E11, E12, E15, E16]. For example, one expert stated:

> *"Well, I am not so sure about whether the PMO should develop and/or mandate a specific code of practice for planning and delivering Megaprojects; however, I think it is a good idea to put best practices for Megaprojects into a standard and allocate the responsibility to follow such standard within the PMO". E12*

The findings show that PMO needs to set out a specific COP to be mandated when appraising and delivering Megaprojects [E10, E12, E13, E14, E15, E16, E17]. Therefore, the experts suggest that the PMO needs to ensure that compliance with the COP by Megaprojects [E10, E12, E13, E14, E15]. The experts also emphases that the PMO needs to keep updating the COP periodically [E10, E12, E13, E15, E16, E17]. One of the experts stated that:

> *"Megaprojects are promoted and delivered within a constantly evolving delivery environment, which is challenging to reflect in a constant code of practice". E17*

The findings suggest that in order to develop the COP, the PMO has to be supplied with high-quality data from Megaprojects to monitor the progress and to make a better decision [E16, E19, E20]. The experts justified this by arguing that it when the data flow from lower-level, i.e. project level to upper, i.e. corporate level that could help to achieve the strategic objectives for the organisation [E16, E19]. Accordingly, some of the experts suggest that the supplied data needs to be supplied with standard form [E20]. For example, one expert stated:

> *"I would like to point out that to develop a code of practice for Megaproject, the PMO should be provided with good data to capture the dynamic nature of Megaprojects … I would suspect the lack of providing such data will result in the impossibility of*

developing a rigorous code of practice similar to what you are proposing". E16

The findings also show that the PMO could engage with the existing related authorities in the UK like the Departments of the UK government, IPA, NIC, NAO to identify and develop best practices, processes, and procedures that promote early engagement of project stakeholders [E19, E20, E22, E23]. For example, one expert stated:

> *"I would suggest that the PMO could engage with the Departments of the UK government and the existing related authorities to identify and develop best practices, processes, and procedures that promote early engagement of project stakeholders". E22*

The experts, therefore, suggest the need for data and knowledge-sharing mechanism to be developed to allow PMO to share data and resources with the existing authorities [E19, E20, E22]. Other experts suggest that the IPA could be part of the PMO that provides Megaprojects on how to use and apply the best practice and expertise in the COP [E22, E24].

Some of the experts express their main thoughts about the limitations associated with the establishment of a PMO by arguing that such measure will increase the level of bureaucracy and complexity in delivering Megaprojects [E24, E25, E26]. One expert stated:

> *"Having this PMO, there will be jealousy between the various civil service Departments… if you look, for example, to the Department of Transport, it has people who would consider themselves to be the PMO within the department looking after HS2, Thames Link, Crossrail 2…. I think this could happen in other Departments". E26*

Some experts argue that such a PMO would have several limitations, especially in the context of privately funded Megaprojects, as some of these will be governed by their sponsors and are unlikely to be governed by the public sector [E24, E25]. The experts also asked how to overcome this issue, some experts suggest that it is possible to provide a threshold that, if privately funded Megaprojects have an impact on the public, environment, or economy that exceeds a certain level, then that project will be subjected to the COP issued by the PMO [E24, E25, E26].

6.5 Code of Practice (COP)

The findings confirm that there is no COP that could inform the developers on how to plan and manage Megaprojects in the UK [E1, E2, E3, E4, E5. E7]. The findings also show that the existing codes of practice for project management do not account for the scale and complexity of Megaprojects [E1, E2, E3, E4, E5]. One expert stated:

> *"The existing risk management processes and procedures are fairly well defined … however, the key issue is they tend to focus on the contingencies rather than on the risk management and mitigations … therefore developing a specific code of practice to address and fill this gap is essential". E3*

Accordingly, the findings suggest for developing a specific COP for planning and managing Megaprojects to differentiate this sort of project from conventional construction projects [E2, E3, E5, E7, E8, E12, E13, E17, E18]. For example, experts justified this and stated:

> *"The existing British Standard does not differentiate between Megaprojects and small projects, and I think there is a need for a British Standard specifically for Megaprojects… I totally agree with having a special one for Megaprojects, and I think we should have it". E5*

> *"I have to side with you on this one that the people are not using the tools effectively, and at the same time I disagree with the fact that there are a lot of tools only focusing on managing risks rather than on managing not getting into the risk for Megaprojects". E7*

The experts were asked about what the new COP should involve managing Megaprojects better. The findings show a variety of perspectives highlighting that the COP should address many aspects: decision-making, risk management, organisational structure, scaling-up and complexity, operability, client capabilities, aligning with and meeting stakeholders' expectations [E2, E3, E4, E5, E8, E10]. Experts justified that by arguing as long as this code is tailored to the Megaproject context, it is up to the developers of this code to accommodate typical measures to manage other MCRs, [E6, E7, E8, E10]. However, the comment below illustrates a typical answer about the content of the code:

> *"I think a code of practice is an interesting idea and should include things like governance, management, approval processes, resourcing, quality control, stakeholder consultation, market engagement, procurement strategy and contracting strategy". E4*

Most of the experts stressed that both scaling-up and the operability of Megaprojects [E1, E2, E3, E4, E7, E8, E9]. For example, experts stated:

> *"I think the principle that you should consider is scaling-up risks should be allocated to the parties best placed to manage them … although this principle could apply to both large and small projects, hence you need extra guidance and attention in the context of very large scale projects like Megaprojects". E5*

> *"I would expect that the lack of operability is one of the main aspects of Megaprojects that need be codified and mandated because such risk is a major threat that causes Megaprojects to go wrong, which eventually tend to threat both project and organisation viability alike". E8*

The findings show that the COP itself can act as a mitigation measure that could manage and mitigate the scaling-up of Megaprojects [E5, E6, E7, E8, E10, E11]. Experts justified this by arguing that such COP would help to equip the Megaproject delivery team with special tools and mechanisms rather than using the traditional tools of conventional projects [E6, E7, E8]. For example, one expert stated:

> *"When things become large they do not necessarily become difficult for Megaprojects to deal with… the one that needs special attention is when it gets to a certain level of complexity and uncertainty or both; then I think it is actually unordinary so you need do something at a different level of project management". E6*

“We can control the scaling-up if we not only better understand the assumption we made and track these assumptions over time ... we can better control the impact of the scale and duration, either by standardise the construction, at least standardised the details of construction”. E11

Findings show that, in order to better manage the operability of Megaprojects, there is a need to establish operability from the outset [E5, E6, E7, E8, E10]. This includes involving senior operator teams during and even before the business case is developed, at a very early stage of the project [E5, E6, E7, E8, E9, E10, E11, E12]. For example, experts stated:

“If you want to develop a business case for a railway project it is not good enough having only construction skills and development skills; instead, the business case developer needs operator skills as well ... in fact, it is a fundamental action to have operator expertise and skills to expand the concept design of a project”. E5

“Operation is crucially important for Megaprojects to achieve commercial viability…I think there is far too little attention given to establishing the operator from the outset … in fact, people tend to think about the operation at the last minute”. E10

The findings stress not only the need for early operational involvement but also the continuity of this involvement [E6, E7, E9]. This because the existing Megaprojects has to continue operating while upgrading takes place, and this is hugely complicated [E5, E6, E11]. Expert stated:

“It will be a complex and challenging task if you are running a metro carrying 60,000 people/hr underground, and you have to continue operating while you are upgrading some technology”. E9

The experts suggest that as long as the PMO is the best authority for standardising best practices and processes for managing and monitoring Megaprojects, the COP could be developed and mandated by the PMO [E10, E11, E12, E15, E16]. One of the experts stated that:

> *"It is not their function to run Programmes and Megaprojects… the centralised PMO function is to make sure you are setting the process controls and best practices that should be followed when the PMO is set up at the project level, and there should be auditing to make sure these processes and systems are followed". E11.*

The experts suggest that the PMO needs to ensure that compliance with the COP by Megaprojects [E10, E12, E13, E14, E15]. The experts suggest that the developer of the COP need to consider and reflect the best practices recommended by relevant authorities and bodies as sources of information and resources [E10, E11, E14, 19]. For example, one expert stated:

> *"It is a quite healthy practice to share data and lessons from the existing bodies in order to minimise the level of conflict because such bodies could impose their own code of practice on Megaprojects as a condition of development during the early conception phase". E19*

The findings also show that because of the turbulent nature of Megaprojects, they require advisory tools rather than mandatory tools [E10, E12, E13, E15, E16, E17]. This is because it is difficult to obtain an agreement on the definition of Megaprojects [E10, E11, E12, E13]. Accordingly, the findings suggest that the COP should be subjected to refinement, amendment, and expansion as necessary [E10, E12, E13, E15, E16, E17].

> *"If the PMO come up with a new thing, then the code of practice has to change … so you need to update the code every time the PMO come up with something new." E13*

The findings suggest that in order to develop the COP, the PMO has to be supplied with high-quality data from Megaprojects to monitor the progress and to make a better decision [E16, E19, E20]. The experts justified this by arguing that it when the data flow from lower-level, i.e. project level to upper, i.e. corporate level that could help to achieve the strategic objectives for the organisation [E16, E19]. Accordingly, some of the experts suggest that the supplied data needs to be supplied with standard form [E20]. For example, one expert stated:

However, some experts expressed concerns about the rationale of having a specific COP. Some argued that one of the key issues in managing Megaprojects is compliance with the codes and guidelines [E22, E24, E25, E27, E28]. One expert argued that:

> *"I'm of the opinion that the problem with all codes of practice is the people do not comply with them". E22*

> *"I think the challenge is keeping enough flexibility in some form of code that looks forward to the future of what might go wrong and does not become overly burdened with some bureaucracy that is inevitably going to be broken by the project… so keeping that flexibility, so the people do attempt to be compliant with … once you have got the flexibility, the other challenge is the interpretation of the code". E24*

Some experts also indicate that the other challenges that would be associated with developing such a COP are the lack of getting the right people with enough experience and expertise to develop the COP [E23, E25]. One expert stated that:

> *"I think the limitation is the designers of such a code have never really envisaged or experienced Megaprojects themselves". E23*

> *"I think there is a shortage of qualified personnel in government in planning and delivering Megaprojects … so I assume it will be a challenging task to develop such code". E25*

6.6 New Form of Contract (NFC)

The experts were unanimous in the view that the existing contracts forms (NEC 3 or 4 as an example) have a number of weaknesses and limitations when applied in the Megaprojects context [E2, E3, E4, E5, E6, E7, E10]. Four broad weaknesses emerged from the findings [E4, E5, E6, E7, E8, E10]: lack of flexibility, lack of interfaces management, lack of managing collaborative behaviour among the contracting parties, and lack of incentivising shared outcomes between the contracting parties. One expert stated:

> *"According to me, scaling-up conventional contractual practices in Megaprojects represents a creation of uncertainty … therefore you need to have a contractual mechanism as well as an operating mechanism that allow you to quickly address these uncertainties and to keep the project moving". E2*

Most of the experts suggest that the incomplete contract by definition could obviously be managed and mitigated under the NFC. [E1, E2, E3, E4, E5, E6, E7, E8]. For example, one expert stated:

> *"I think the current contracts do not recognise the inevitability of change and do not provide mechanisms for fairly dealing with change in Megaprojects ... so I would recommend for a modified version of the contract that could address this risk of incompleteness in programs". E1*

Based on the above weaknesses and limitations, the experts were asked about the viability of developing a NFC specifically for Megaprojects, and they positively recommended a NFC with four broad suggestions to address and overcome the above weaknesses in Megaprojects context [E4, E5, E6, E7, E8, E10]. These are developing a selectively flexible contract; management of interfaces, modelling collaborative behaviours, and incentivise shared outcomes. For example, one expert stated:

> *"I would recommend modifying the existing contract systems to address both the lack of flexibility and interfaces in Megaprojects, take Crossrail as an example, which is developed in 2005, now we are in 2017 where many things have been changed ... the tender stage took place in 2005 or 2006 where there was a set of assumptions made, over time these assumptions have been changed, which create many interfaces and a lot of changes, and these changes caused an excessive delays, and there are commercial consequences". E10*

The findings of each one of these suggestions are provided in the following sections.

6.6.1 Selectively Flexible Contract

A common view that emerged from the interviews was that the existing contract systems are not flexible and adaptable enough to the ever-changing nature of Megaprojects [E7, E8, E9, E10, E11, E13, E15]. The experts argue that lack of flexibility in Megaprojects largely derives from the tendency among the clients to transfer even more risk to the supply chain [E7, E8, E9, E10, E11]. The experts also pointed that the clients of Megaprojects tend to add more restrictions and constraints into their contractual arrangements, which in turn make it less adaptable enough to the turbulent environment around Megaprojects [E7, E9, E10, E11]. One expert stated:

> *"If a government really does want to retain maximum flexibility when implementing a Megaproject, then it should use only short-term contracts and should not use private finance". E10*

In response to this issue, some experts suggest that there is a need to have a mechanism that could provide flexibility as needed to overcome the rigidity and the restrictions in the existing contractual arrangements [E7, E8, E10, E11, E12, E13]. To improve the practice, the experts suggest that a NFC for Megaprojects could be selectively flexible based on the level of uncertainty [E12, E13, E15, E16, E17]. One expert stated:

> *"We should be selectively flexible on those elements where emergencies might happen, and you can think about value gain sharing, you could call it emergent issue resolution". E13*

The experts elaborated more on this point by showing that if the client is in a situation where the design is well understood and by-and-large complete, and there is a low likelihood of changes, then the client is more likely to have a fixed-price contract [E13, E14, E16]. However, if the design is not very well understood and is subject to a lot of changes, then the chances of the client wants to just go on a target-cost reimbursable form of contract are much higher because it is a safer option to protect the client from claims from the contractors [E13, E14, E16, E17]. One expert gave an example and stated:

> *"When building the Channel Tunnel between England and France, we used three different contract price regimes according to what*

made most sense: (i) above-ground structures such as terminal buildings were built on a fixed-price basis; (ii) the tunnel itself was built on a target-costs basis; and (iii) the rolling stock was procured separately on a semi-fixed price basis". E14

The experts show that using a selectively flexible approach can be further improved by scaling it down to the activity level, i.e. using multiple types of contracts with the same contractor under different options based on the level of uncertainty [E13, E14, E15, E16, E18]. For example, it is possible to use a lump sum if the project manager knows what the material is, and use a target cost with high interface risk. As another example, in a railway station, it is possible to have one contract for the shell of the station, which is a civil structure, and another contract for the system fit-out [E13]. The findings confirm that using a selectively flexible contract down to the activity or sub-contractor level could make the contract more flexible than it is really designed to be [E14]. For example, one expert stated:

"The same principle selectively flexible contract is currently being used by Mac Macdonald in advancing a major client for a multimillion-pound piece of work because the client for whatever reason wanted everything to be done within one contract". E15

6.6.2 Management of Interfaces

A common view amongst the experts was that the second weakness in the existing contract arrangements is around managing the interfaces between Megaproject packages (overall programme integration) [E14, E15, E17, E18]. One expert stated that:

"One of the distinguishing differences between Megaprojects and conventional projects is purely the scale of contracts with numerous interfaces, which unfortunately is not recognised by the existing systems". E18

For effective interface management, the experts suggested that both parties (client and the supply chain) would need to be legally responsible to deal with interfaces by identifying them and then managing them by allocating this job to the best person, similar to risk management because it is a shared task [E14, E15, E18, E19]. The issue is how to break them down properly, and obviously how the two parties manage the interfaces between themselves [E14].

Further, the majority of experts agreed that in order to manage the interface there is the need for a mechanism, where the interfaces can be captured and tracked into the contract [E14, E15, E16, E17]. The obvious approach is to procure all packages concurrently or at least within a common framework [E14, E15, E16, E17, E18, E19, E20]. For example, an expert stated:

> *"Scope down the work into small packages, and refine the requirements as you know more, and try to know what the interfaces are as you know more, and the integration responsibilities as well". E21*

The findings suggest that such a framework should have a way of integrating the performance to the specification, so when a party identifies an opportunity or makes a change, they will understand what the overall or overarching system performance impact would be, which would enable each party to effect a solution to the design to maximise the overall performance [E14, E21]. The findings show that the interface management between systems is a crucial part of project governance [E14, E15, E16].

6.6.3 Modelling Collaborative Behaviours

The findings revealed that the third weakness in the existing contractual arrangement is the poor collaborative behaviour among the contracting parties [E19, E20, E21, E22, E23, E24]. For example, one expert stated:

> *"What I think, in my opinion, is there's nothing wrong with the standard form of the contract, it is entirely down to the culture and the behaviours of the organisations that sign up to those contracts, either if they are the client or the contractor or people further down in the supply chain". E22*

The experts confirm that the construction industry in general and Megaprojects in particular still do not understand or appreciate the behavioural awareness and behavioural science [E20, E23, E24]. For example, one expert stated:

"I think the general level of the intelligence in construction is average at best and when you are talking about psychology and behavioural modelling, understanding the dynamic of the team performance, that is a step up from the level of the intelligence and awareness that you typically see in most contractors and client organisations". E20

In response to this weakness, the experts suggested a need for intervention actions that would increase the level of collaboration among the contracting parties [E19, E20, E22, E23, E24]. The experts expressed the need for codifying and modelling what good collaborative behaviours manifest themselves generically [E19, E20, E21]. For example, experts stated:

"I would suggest developing a mechanism that could quantify, measure, and evidence the collaborative behaviour among contracting parties". E19

"If you get the culture of collaboration right in your organisation, either if you are a client or a contractor, then you instantaneously give a much better sign of success, people are happy, they work together". E21

6.6.4 Incentivise Shared Outcomes

The findings also show that the existing contract systems have a number of weaknesses with respect to aligning the outcomes between the client and the supply chain [E23, E24, E25, E26]. For example, one expert stated:

"The existing contract only allows for temporary integration between the client and the supply chain rather than long-term integration". E25

In response to these weaknesses, experts suggested that it is essential to have a better degree of integration throughout the top project team down to the bottom teams [E23, E24, E25]. Experts added that there is a need to drive down the accountability into the supply chain because organisations in the supply chain have a tendency to focus only on their tasks and packages, and not look at the overall picture of the project [E23, E24, E24, E25]. One expert stated that:

"The contract also should place more requirements on the supply chain tier, one to actually engage their supply chains in the contractual arrangements". E26

To achieve such integration, the fourth suggestion by the experts is to build within the contractual arrangement a mechanism that could incentivise the shared-outcomes schemes for both client and supply chain [E25, E26, E27]. This incentive scheme can ensure that the contractor earns more money based on the project outcome. For example, one expert stated that:

"In the London Olympics 2012, a shared-outcomes scheme was applied but only on the tier one level rather than the supply chain". E27

6.7 Summary

The chapter has presented the findings of empirical research using Adaptive Grounded Theory Interviews. In total, more than 28 semi-structured interviews were conducted Megaproject experts to collect high-quality data about how to better how to manage and mitigate MCRs collectively. The chapter has presented an overall picture of the data and the findings by showing the emergent themes from the fieldwork phase. Four main themes were discovered as measures to effectively manage and mitigate MCRs. These are legislating and enabling a specific ACT for Megaprojects, developing a specific PMO at the national level, developing a specific COP for Megaprojects, and developing a NFC for Megaprojects. These four themes are discussed further in the subsequent chapter of this thesis.

Chapter 7 Development and Validation of the Proposed Approach

7.1 Introduction

This chapter aims to discuss the development and validation process of a new approach to risk management in Megaprojects based on the research findings on the AGT process presented in Chapter 5. The current chapter consists of six sections, including this introduction. Section 7.2 defines the proposed approach by briefly outlining its main elements. Section 7.3 describes and discusses the development and validation process of the proposed approach. Section 7.4 discusses the structure and content of the AGT findings with respect to the four themes: ACT, PMO, COP and NFC, which collectively constitute the new approach to risk management for Megaprojects. Section 7.5 discusses the approach's validation process using the Delphi technique. Lastly, the chapter summary is presented in Section 7.6.

7.2 Proposed Approach Definition

The current research aims to improve risk management in Megaprojects by proposing a new approach to risk management beyond conventional risk management approaches that are currently applied. The proposed risk management approach is designed to provide a structured methodology that will help Megaproject practitioners to identify and differentiate MCRs from conventional risks and provides them with a new set of mitigation measures to manage and mitigate these MCRs collectively in a better way. Hence, it can be applied consistently and systematically across all Megaprojects and only Megaprojects. The proposed approach is unique in that it comprises for the first time a combination of four practical proposals for MCR mitigation measures (ACT, PMO, COP, and NFC). Until now, there has been no such comprehensive approach; this research study is the first to attempt to do this. These mitigation measures proposals are described with further developed details in Section 7.4 and validated in Section 7.5. The proposed approach should be viewed as an important component within the holistic and proactive project management for

Megaprojects and similar Programmes. It should not be seen as being conclusive for the identified MCRs in this research. It does, however, cover the mitigations of most relevant elements of MCRs deemed crucial for the delivery success of all Megaprojects by both client and supply chain organisations.

7.3 Proposed Approach Design and Development Process

This section aims to discuss the design and development process of the proposed approach, which is guided by the adopted research methodology, as discussed in Chapter 5. The design and development process can be broken down into three phases: pre-fieldwork phase, fieldwork phase and post-fieldwork phase, as shown in Figure 7.1.

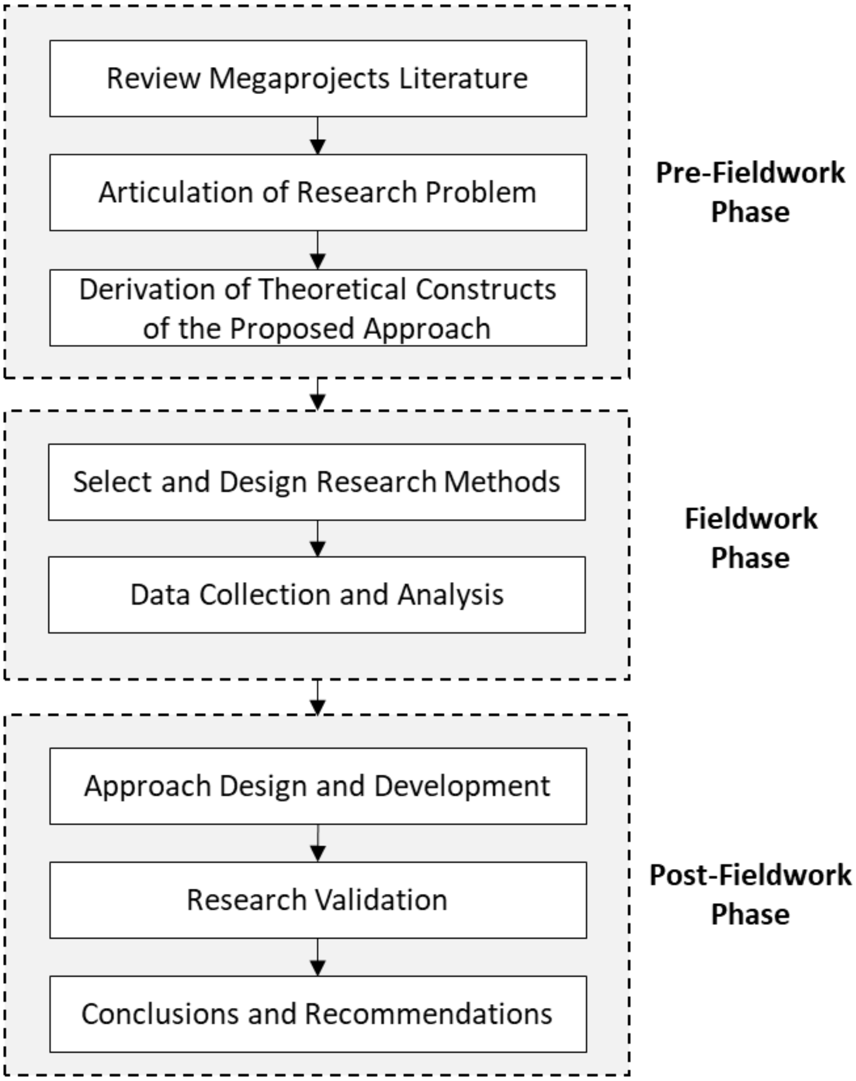

Figure 7-1 Proposed Approach Design and Development Process

In the pre-fieldwork study phase, a rigorous literature review was carried out in both Megaproject and Risk Management areas. The outcomes of this phase helped to highlight the gap in knowledge, forming the problem statement, and the articulation of research aim and objectives. During this phase, MRs were investigated and differentiated from conventional risks by using content analysis. The outcomes of the content analysis were used as a source to identify MCRs using a systematic process, as discussed in Section 5.5.

The pre-fieldwork phase also involved a rigorous literature review to identify a comprehensive list of recommended mitigation measures for Megaprojects. Producing such a comprehensive list was used as the main source for the theoretical derivation of CMMs for Megaprojects. The shared elements between MCRs and CMMs were then investigated and integrated to generate theoretical linkages to justify the rationales of the proposed approach of risk management in Megaprojects.

Thus, the theoretical constructs of the proposed approach were used as the main vehicle for collecting empirical data in the fieldwork study phase. Accordingly, the fieldwork study phase included applying appropriate research methods to collect and analyse the data required to achieve the research aim and objectives. Therefore, AGT was selected and justified as the most appropriate method for the current research after investigating and comparing the existing research methods in the project management arena. During this phase, the AGT interview was applied as the most effective technique to collect high-quality and in-depth information from experts in Megaprojects. The collected data were analysed using a systematic coding process, as discussed in Section 5.7.3. This phase resulted in presenting and structuring the research findings from the AGT interviews.

In the post-fieldwork study phase, the empirical findings were discussed and compared with the literature review to design and develop a new approach to risk management of Megaprojects. This proposed approach was shaped based on the understanding and interpretation of the empirical research findings, which consist of four MCR mitigation measures proposals (ACT, PMO, COP and NFC) as discussed in Section 7.4. During this phase, the proposed approach was validated using a Delphi validation technique after three rounds, as discussed in

Section 7.5. Based on the discussion of the validation results in Chapter 8, conclusions and recommendations for future research were derived and are presented in Chapter 9.

7.4 Proposed Approach Structure

7.4.1 Act of Parliament (ACT)

The research findings in Section 6.3 suggest legislating for and enabling a specific Act of Parliament (ACT) for Megaprojects in the UK similar to the concept of Public-Private Partnership (PPP) acts and laws in other countries like France or the UAE [5]. The findings in Section 6.3 suggest that the new ACT will help in developing practical measures to manage and mitigate some of the MCRs like Adaptability to Legislative and Political Changes. It also suggests that ACT needs to accommodate provisions allowing compensation to cover the costs associated with non-commercial risks that have significant impacts on Megaproject performance. This includes obtaining government guarantees to adjust tariffs or extend concessions if legalisation changes occur. By extending the concession periods, the government can protect the concessionaire from the loss caused by legislation changes. The extension has to be matched with a concession period long enough for the sponsors and lenders to recoup their outlays and remuneration, bearing in mind the length of maturity of the loans advanced [23]. For example, in the Shajiao B power project in China, the government agreed to extend construction and operation periods if the delays had resulted from force majeure events [476].

The findings in Section 6.3 also suggest that the ACT could involve a legislative changes exemption mechanism to increase the adaptability of Megaprojects to legislative and policies changes, as shown in Figure 7.2. The suggested mechanism allows a Megaproject's sponsors and clients to seek exemption from the legislative changes, where exemption conditions could be set by high commissioning authorities (mechanism commissioner). This mechanism focuses on changes in local laws (bylaws) and local regulations because it is more challenging to exempt Megaprojects from changes in laws at the national level as those have national significance.

In the UK context, the concept of this mechanism already exists; however, it is only applied at the contract level. For example, in the contractual arrangements of a transport Megaproject, there will be a clear provision that the Department for Transport will compensate for the changes in a particular regulation or legislative change. Accommodating such a commitment to the contract will provide some certainty around such changes; however, and more often, it is easy to break these commitments. Therefore, establishing a new mechanism under the law (Megaprojects Act) will increase the level of certainty around the legal environment in the UK. This measure will be appreciated by almost all the Megaproject parties, except politicians, because they will have less freedom to enforce their agendas and policies by changing laws and regulations.

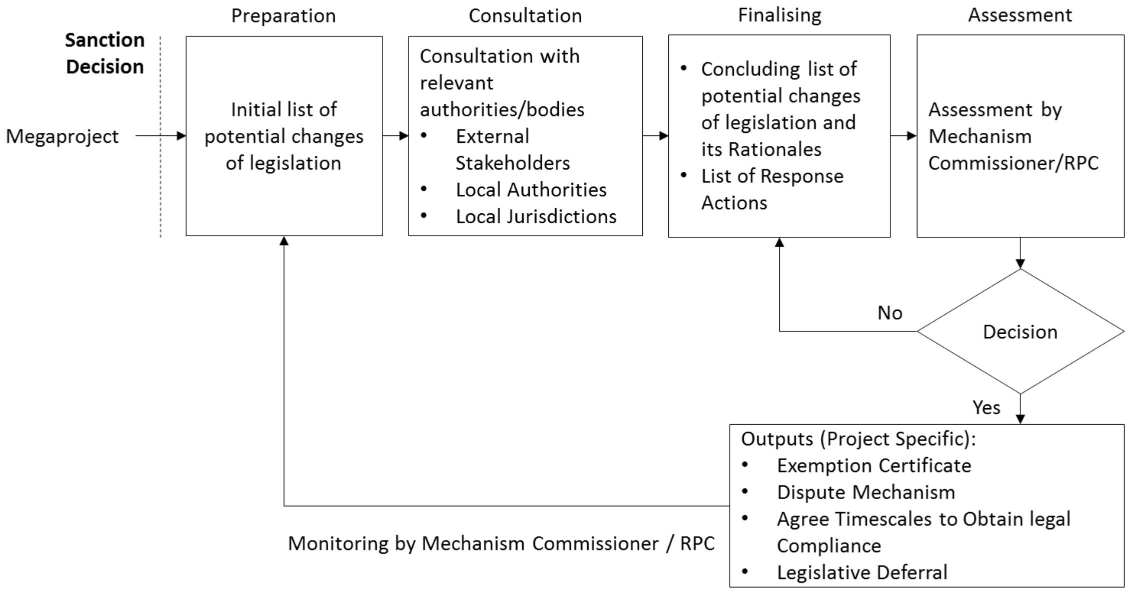

Figure 7-2 Legislative Changes Exemption Mechanism

The timing of this mechanism is flexible; however, a Megaproject needs to have a reasonable level of maturity before starting with the exemption process, i.e. to pass appraisal phases. This could be justified since Megaproject developers tend to move the project along quickly because it takes a lot of time to complete. This means some of the works will be undertaken in parallel with the sanction process. Further, during the appraising phase, Megaprojects are more adaptable to legislative changes because there are fewer financial commitments and obligations to be made compared with at the implementation or operational phases. One of the experts who was interviewed gave an example and stated that "… for example, taking the HS2 perspective, the project started through a hybrid bill process to get Royal Assent, and there were already 1500 people working on the project… so it is difficult to rush the parliamentary process".

Under this process, a Megaproject's project team will ask the mechanism commissioner to start with the exemption process, which needs to have the required capabilities and authorities. The project's sponsor or client needs to identify the list of legislative changes (local laws and regulations) to be exempted from. The mechanism commissioner may request the project's sponsor or client to conduct extensive consultations with local authorities to make them agree on the list. The project team should also provide explicit and well-evidenced rationales behind special legislative exemption requests and what alternative solutions are favoured, which they will also provide. Accordingly, the project team needs to provide the mechanism commissioner with an action plan and a list of mitigation measures as an alternative to comply with these legislative changes.

Once the mechanism commissioner has received the list of potential legislative changes to be exempted, the mitigation action plan against these changes and the rationales behind these exemptions, it will assess them to make a decision. The findings in Section 6.3 underline that the mechanism will face some challenges because there are many variables associated with legislative changes. The legislative changes could be related to national laws, local laws, regulations or policies; therefore, different capabilities are required to assess these legislative changes, depending on their nature. Moreover, some of this legislation will affect the business case, while other parts may not, which also requires special capabilities. Therefore, the mechanism commissioner may recruit specific bodies to help with the assessment, according to the nature of the legislative changes. For example, the Regulatory Policy Committee (RPC) could be employed to carry out a costs and benefits assessment specifically in relation to regulation changes and identify the effects these changes may have. This is because the RPC is an advisory, non-departmental public body that provides the government with external, independent scrutiny of new regulatory and deregulatory proposals [283].

After assessing the documentation mentioned above, the outcome of the mechanism will be a certification letter from the mechanism commissioner to the project/programme notifying it of the mechanism commissioner's decision. The certification letter is not generic; instead, it needs to be specific depending on the project context with a timeframe. For example, the output of the certification letter would state that project X is exempted from legislation A and B for two and six years, respectively. The mechanism commissioner should also provide explicit and well-evidenced reasons for why particular recommendations have been made. For example, the mechanism commissioner needs to give rationales for which legislative exemption requests are rejected. The mechanism commissioner may provide legislative deferrals for specific legislation, which provides an optimal solution for both sides – the mechanism commissioner and the project. This could include providing a permission or allowance period to comply with a particular piece of legislation instead of a complete exemption, to avoid any turbulence and to give the project team some opportunity to adapt and make corrections. For example, if a new Human Resources (HR) legalisation came into effect in project Y with 50,000 people, it might take a long time to be sorted out, which could cause massive turbulence to the project. For this example, the certification would say that project Y has two years to comply with this HR legalisation after the date at which it came into effect.

After issuing the certification, the mechanism commissioner/RPC will monitor the project team's progress towards the certification requirements. This is to make sure that these requirements are applied and the mitigation measures are active. Therefore, the mechanism commissioner will update the exemption status and may disqualify Megaprojects from these exemptions if they find that the projects do not comply with the requirement. The mechanism commissioner also may need to establish a warning system to inform project teams about their compliance. The mechanism commissioner also may allow for suspending compliance with changes in laws, policies and regulations for a defined period to reduce the turbulence that could result from instant compliance.

Because the project team typically does not focus on legislation changes, the mechanism commissioner will also be continually scanning for new legislation and will inform the project team about these changes. Furthermore, although many legislative changes could occur, only some of them might be relevant to a project. Therefore, there is a need for a central authority and feedback loop that can look at legislative changes and inform Megaprojects about their impact. This process needs to notify projects on a periodic basis (every year, or six months, for example) that new change is happening and is going to impact their outputs and/or outcomes. The mechanism commissioner, therefore, could employ relevant bodies such as the RPC as they are always looking for regulatory changes happening in the UK, whereas the project team is not.

Irrespective of what the new ACT will deliver for Megaprojects, it should be consistent with the country's legislation, including general framework and sector-specific laws. Furthermore, it is essential that the new ACT does not contradict others and that the application of individual Acts is easily understood [477]. Therefore, and to avoid confusion, amendments to all potentially conflicting laws should be made to achieve consistency.

7.4.2 Project Management Office (PMO)

The findings in Section 6.4 strongly confirm that Megaprojects are commonly affected by lacks in two areas: first, they lack the right capabilities and skills; this is especially the case in public sector organisations at the national level. Second, they lack an adequate and robust strategic oversights process. This is confirmed by a recent NAO report which has found that one of the challenges faced by the UK government is that weaknesses in capability undermine the government's ability to achieve its objectives [478]. The same report pointed out that people with the experience and skills to deliver complex projects, particularly within a government context, are in short supply [478].

The findings in Section 6.4 suggest a new governance system for Megaprojects based on the establishment and intervention of the national PMO in the Megaprojects context, as shown in Figure 7.3. The development of the PMO requires the power of the ACT and will have a budget to invest as well as special project development and planning powers. The findings in Section 6.4 seem to be in line with the above recommendations as they suggest establishing a Project Management Office (PMO) at the national level. This PMO will become a central organisation that is the enabling engine for Megaproject delivery, achieving the highest degree of efficiency and effectiveness and the most significant sustainable impact on global aspects: social, technical, economic, environmental and political (STEEP). Therefore, the PMO can help in achieving the organisation's financial and strategic goals.

The findings in Section 6.4 suggest that the main role of the PMO is to monitor the delivery of Megaprojects. Accordingly, there is a need to establish a line of sight to mandate and advice best practices, processes and procedures from the PMO down to the supply chain at the lower levels. Therefore, this study suggests that the PMO should develop and administer a specific COP, which needs to be revisited and updated from time to time to cope with the evolving nature of Megaprojects. The PMO should explicitly clarify and describe what outcomes are needed and provide best practices to achieve them. The PMO should institutionalise organisational processes and methodologies to all Megaprojects.

The PMO needs to ensure that compliance with the COP is a condition of the contract(s) between the project’s sponsor and the delivery organisation as well as the contract(s) between the delivery organisation and its first-tier contractors and subcontractors. The PMO also needs to ensure compliance with the COP throughout the whole life cycle of the project. Therefore, the PMO will undertake appropriate monitoring to ensure that the Megaproject complies with the COP. To achieve this, several tools could be used, such as a doors requirement management tool, which has a list of requirements and how these requirements should be met.

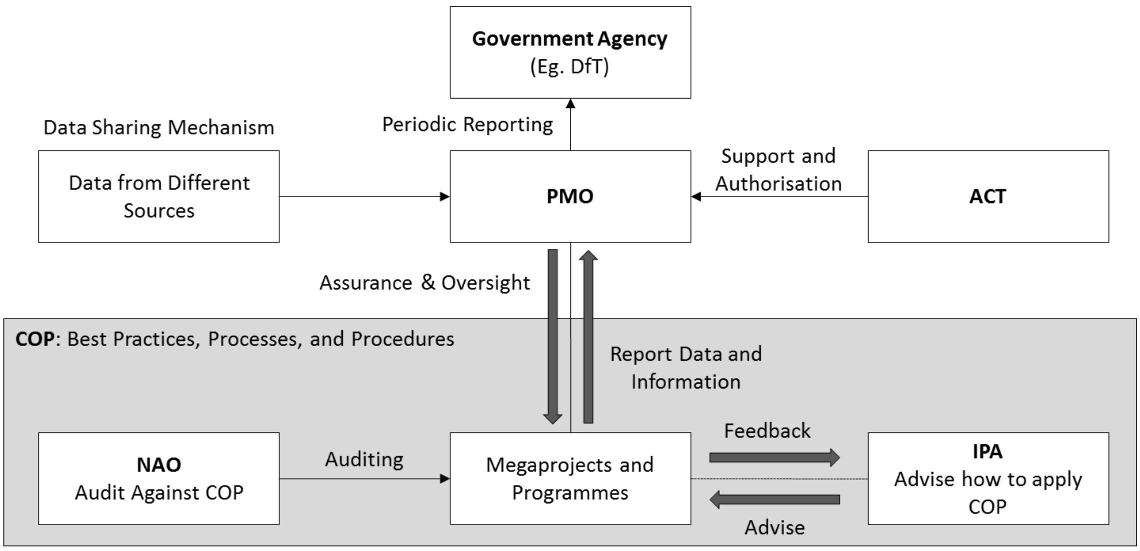

Figure 7-3 Megaproject Governance Model

In the proposed governance system, the PMO has to be supplied with data from Megaprojects at the lowest level to monitor the progress and to make decisions. Therefore, there is a need for a standard form to standardise data collection, which allows the data to be compared and analysed. A recent NAO report has shown that UK Government Departments do not provide or report back the progress of their projects consistently to the IPA [19]. This is not good practice to measure success across Megaprojects, which justifies the rationales of reporting and standardising data to the PMO. For example, if the PMO wants to measure the earned value formation of all Megaprojects and Programmes, the draft framework has to say that suppliers must provide and report back earned value information.

The PMO also needs a data and knowledge-sharing mechanism with the existing authorities and other resources such as the NIC, IPA, the Regulatory Policy Committee (RPC) and other relative bodies. For instance, it is important that the strategic vision of the NIC is reflected in the COP to improve the delivery of Megaprojects. Furthermore, the other sources of data would come from the local councils in which Megaprojects are delivered; so, for example, if the project is in London, the PMO might need information from any local authorities and HM Treasury (i.e. spend information). Therefore, a Responsible, Accountable, Consulted and Informed (RACI) matrix or stakeholder map for Megaprojects could be used to map how and where the data would come from. The findings in Section 6.4 suggest that the NAO needs to engage more with the proposed governance system to audit the progress and report back to the PMO.

Based on the findings in Section 6.4, this study argues that it is much better to separate the existing authorities such as NIC and IPA and the role of the PMO to increase the level of accountability and transparency. The rationales behind this are that the NIC advises the government on what it should do rather than how it should do it. For example, the NIC advises on whether the UK government should invest in high-speed transportation systems such as Hyperloop, or invest in road charging, etc. Furthermore, the IPA will act as an advisory authority on how to implement the COP.

After analysing the data, the PMO would give information and feedback to Megaprojects, as shown in Figure 7.3. The findings also show that the PMO would also provide progress reports to the relevant agencies, authorities and departments at the national level and update them about the progress to aid their decisions. For example, with High Speed 2 (HS2) the feedback report would be sent to the Department for Transport, or, if the Megaproject was concerned with building a new school, the report would go to the Department for Education.

7.4.3 Code of Practice (COP)

The empirical findings in Section 6.5 confirm that there is no COP for planning and delivering Megaprojects. Therefore, the findings of this study presented in Section 6.5 call for the development of a new COP specifically for Megaprojects to accommodate the best practices, processes and procedures for planning and delivering such projects. This suggestion seems to be consistent with the recommendations of a recent report by the Oil and Gas Authority (OGA), which has stated that in order to improve the success rate for projects it would be useful for the OGA to develop a more rigorous framework and COP for the submission of prospective projects and associated Field Development Plan (FDP) [479]. This will ensure that projects have been thought through fully at very early stages.

The findings in Section 6.5 suggest that the COP should be comprehensive to ensure that Megaproject developers are equipped with the best practices, processes and procedures to plan and deliver their Megaprojects in the best way. These findings indicate that the COP should address many aspects such as project governance, organisational design, special purpose vehicle (SPV), minimum requirements for the stage gates process, resourcing, quality control, decision-making, contract and procurement, risk management capabilities over project organisation, aligning stakeholder views and consultation, etc.

The findings in Section 6.5 suggest that the COP should reflect the principles of the ACT for Megaprojects in order to translate these principles into well-defined practical and contractual obligations. It should also reflect the best practices, processes and procedures set by the PMO, as shown in Figure 7.4. For example, if the PMO states that the supply chain needs to know what are the top risks and what are the mitigations, then it is up to the PMO to ensure that best practice achieves these outcomes as clearly and concisely articulated in the COP. The findings suggest that the PMO would be responsible for standardising best practices, processes, procedures, tools and methodologies for managing and monitoring Megaprojects; hence the PMO is the most suitable authority to develop and mandate the COP. The development of the COP requires the PMO to consider and reflect the best practices of bodies that are relevant to Megaprojects such as the local authorities, NIC, NAO, etc. This will minimise the level of conflict because such bodies like the city council will aim to impose their own COP on Megaprojects as a condition of development during the early conception phase.

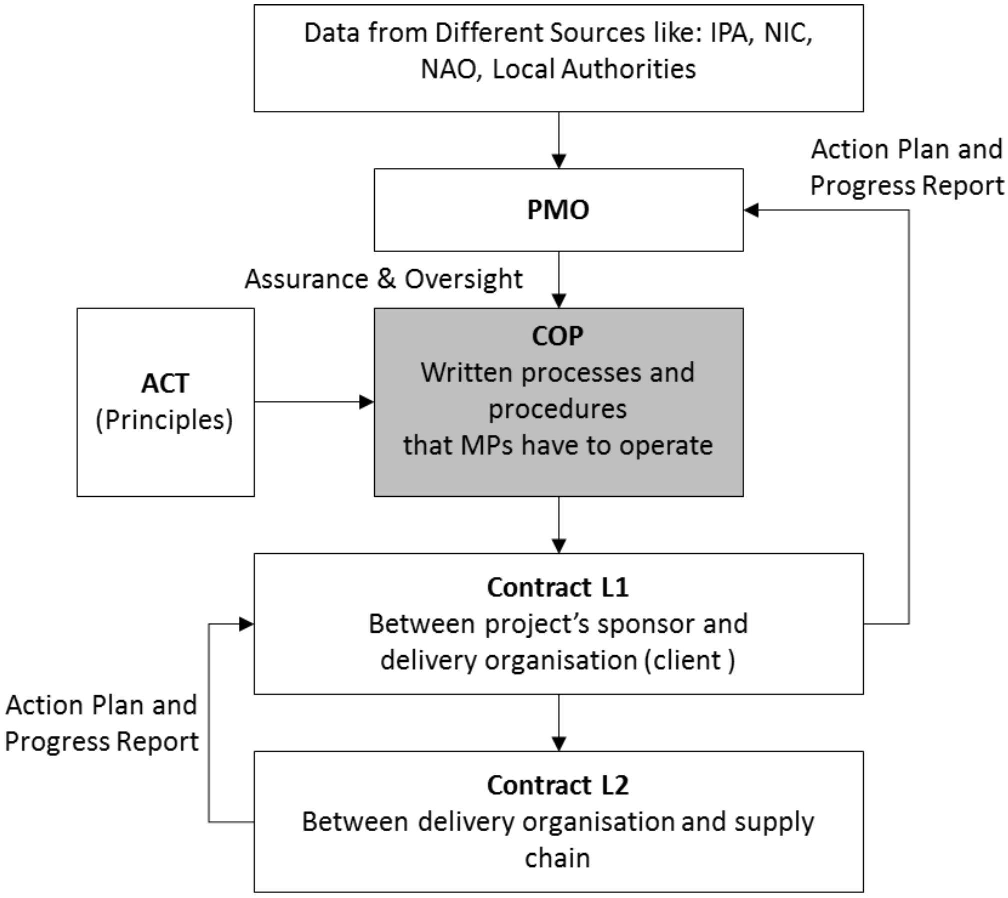

Figure 7-4 COP Development Process

The findings in Section 6.5 suggested that the development process of the COP requires high-quality data to capture the scale and dynamic nature of Megaprojects. Accordingly, the developer of this COP, i.e. the PMO, has to be supplied with high-quality data to support the ongoing monitoring and oversight process. Such data could be provided from different sources including internal sources like lessons and legacies of Megaprojects or external sources like best practices, procedures and processes from industry and/or governmental organisations like local councils, major project associations, EY, NIC, IPA, HM Treasury, NAO, etc. For example, if the project is in London, the PMO might need information from any local authorities and HM Treasury (i.e. spend information). Furthermore, it is important that the strategic vision of the NIC is reflected in the COP to improve the delivery of Megaprojects. The findings in Section 6.5 suggest that there is a need for a standard form to supply the data from both internal and external sources. The main rationale behind this argument is standardising data collection allows the data to be compared and analysed by the PMO; hence developing a rigorous code of practice.

The COP should be updated on a periodic basis to reflect new best practices and to cope with the evolving nature of Megaprojects. Thus, for example, if the PMO needs to make changes as a response to risk management change, then the COP has to be modified in accordance with the new practices. Therefore, the PMO should take into consideration the implications that could result from changing or updating the COP. However, the findings in Section 6.5 argue that the frequent changes in the COP will leave room for uncertainty unless the required outcomes are clearly and specifically described in the COP.

To implement the COP, the findings in Section 6.5 revealed two views. The first one suggests that the COP needs to be imposed on Megaprojects and enforced by the PMO. The second view suggests that the COP should be advised and consulted by the Megaprojects. However, if the PMO recognises that a project's team is not complying with the COP, the PMO will mandate the project's team to comply with it. This research stands with the second view, as this provides more flexibility and adaptability to comply with the COP due to the changing nature of Megaprojects and their surrounding environment. The COP will be implemented at a very early appraising phase until project close-up. A Megaproject's client and their supply chain will be required to comply with the terms of the COP. The client must ensure that their first-tier contractors and subcontractors comply with the COP. Therefore, the client may need to prepare an action plan to be submitted to the PMO to demonstrate how they will comply with the requirements of the COP. Similarly, the supply chain may need to prepare an action plan to be submitted to the delivery organisation to demonstrate how they will comply with the requirements of the COP.

7.4.4 New Form of Contract (NFC)

The interpretation of findings in Section 6.6 suggests that there is a need for a NFC for Megaprojects to overcome the issues mentioned above. The findings in Section 6.6 show that the NFC needs to accommodate four critical features in contractual provisions, as shown in Figure 7.5. The first feature is that the NFC needs to focus on the accountability of managing the interfaces (programme integration) at the outset by clarifying and justifying the roles of the key parties, especially the client. The second feature of the NFC is to promote and deploy collaborative procurement behaviours among the contracting parties (client and the supply chain). The third feature is about managing the accountability of the supply chain organisations in delivering the project as a whole, instead of focusing on their temporary packages and undertakings. Lastly, the NFC needs to be selectively flexible instead of being a completely fixed contract or fully flexible. The findings around these four features are discussed in detail in the following subsections.

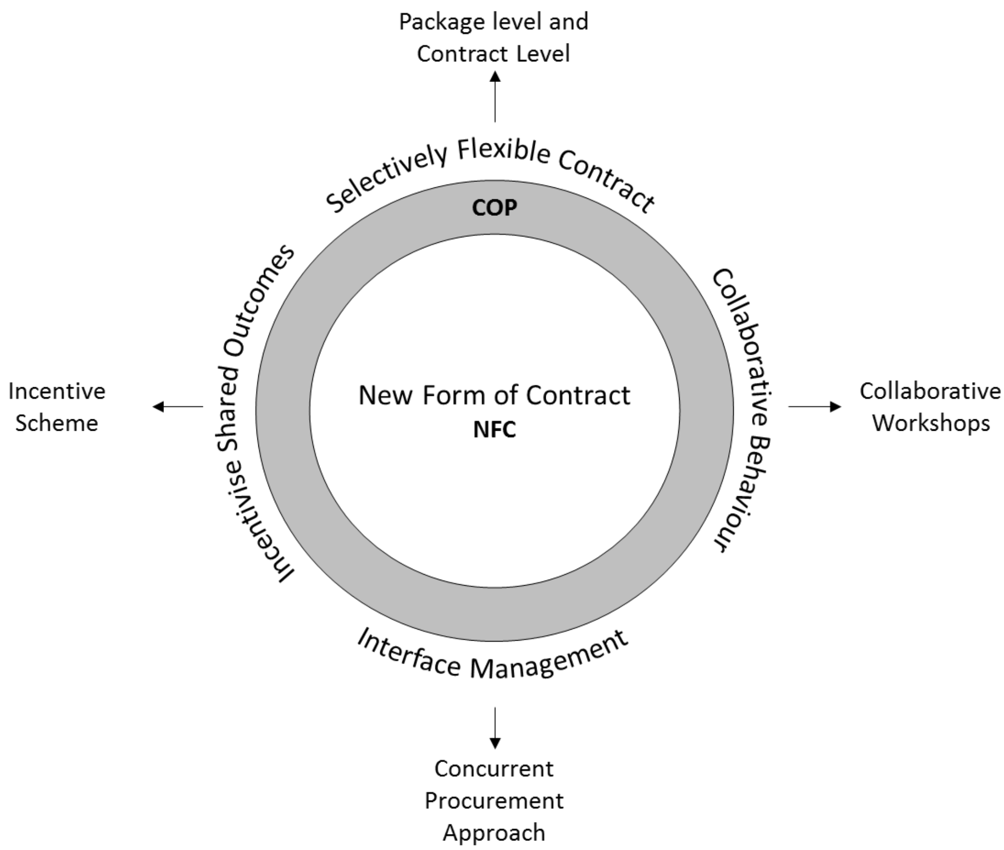

Figure 7-5 NFC Elements

7.4.4.1 Selectively Flexible Contract

The findings in Section 6.6.1 suggest that Megaprojects require a NFC that could deliver flexibility as required. These findings suggest that a Megaproject could be broken down into distinct packages and elements, each of which addresses a different aspect of the uncertainty. Depending on the uncertainty level, each package would be delivered by the most appropriate type of contract, which would range from fixed contract arrangements to fully flexible contract arrangements.

For example, in a Megaproject, a fixed-cost contract could be used to deal with packages that contain standardised, typical and repetitive activities, whereas a target-cost contract with an activity schedule could be used on packages associated with a high level of uncertainty. For example, in a railway Megaproject, a fixed-cost contract could be used for stations, a target-cost one for the trains, and another contract option such as cost-plus for the signalling software because it is new and evolving, and there is high uncertainty around it.

The London 2012 Olympics used a selectively flexibility contract approach to great success, relying on fixed-price contracts to deal with known conditions and risk-sharing and target-cost contracts (including contracts based on a suite of what have been called NEC) to deal with less predictable projects, such as the construction of the London Aquatics Centre, the Velodrome and the Olympic Stadium (now the London Stadium) [186]. According to this example, this approach is applied at the project level, i.e. each work package is let with a different contract framework. That means the existing practices tend to let every single contract with a sole supplier. However, applying this approach at the project level has a number of challenges. For example, it is very difficult to incorporate changes and adjustments in fixed-cost contracts whereas, with flexible contract options, bidders tend to underbid, so if the job is £400 million, they will bid £300 million because, with a flexible contract, it is easy to change the target and the cost.

The study suggests that enhancement towards flexibility can be obtained further by breaking down each package into distinct sub-packages based on the uncertainty level, where each sub-package can be delivered by a different form of contract. This can help increase the level of flexibility and the adaptability to risks and uncertainties, which eventually helps to reduce the incompleteness of Megaprojects. This argument seems to be consistent with other research which found “some relaxation of the specifications for, say, schedule and project controls tools could encourage the use of more flexible and more appropriate approaches” [6]. However, the management of different types and forms of contracts has turned out to be a huge challenge by itself, and even more challenging is managing the interfaces that could result between these contracts [158]. Therefore, there is a need to increase the capability of the client to manage those multiple frames of contracts. The findings in Section 6.6.1 suggest scaling-down the concept of a selectively flexible contract to the package level, i.e. incorporating and integrating a whole range of contract options (fixed cost, target cost or reimbursable elements) with a single supplier. This suggestion could enhance the existing practice because the work will be undertaken with: less effort, less complexity, and fewer interfaces.

7.4.4.2 Management of Interfaces

The findings show that to manage interfaces better the project team needs to scope down the work into small packages, refine the requirements as they know more, and try to know what the interfaces are as they know more, and the integration responsibilities as well. The findings also argue that the obvious approach is to procure all packages concurrently or at least within the concurrent approach. This approach should also be agreed before starting the procurement of any of the packages. It is based on the parallelisation of activities whereby most of the project packages can be integrated to reduce the time needed during the implementation of the overall project. Further, it allows design and construction to proceed concurrently within a contractual framework and accordingly, key risks to the project can be known and managed by all parties [480]. The Big Dig is an example in which the concurrent system is applied in procuring lighting, utility placement, and air and heating ducts [41]. Under this approach, project managers will be able to manage interfaces between different contract packages concurrently and deliver their projects successfully. Many tools can be utilised to facilitate the implementation of concurrent communication, early contractor/operator involvement, and modularisation and standardisation.

7.4.4.3 Modelling Collaborative Behaviours

In this research, the findings in Section 6.6.3 highlight that there are some weaknesses in the existing contract systems in terms of supporting the collaborative behaviours. These findings suggest that the collaborative behaviour needs to be codified, quantified and measured to manage and mitigate incomplete contracts. These findings match the argument in a recent paper by Smith and Jobling [6], which argues that incomplete contracts require collaborative processes between contracting parties to be realised which are beyond the familiar and conventional contractual practices. The interpretation of the findings revealed that there is a need for a mechanism to quantify, measure and provide evidence for the collaborative behaviour among contracting parties. It also needs to observe someone behaviours over a period of time to establish whether or not that person is fundamentally collaborative or not. This mechanism could classify the collaborative behaviours into different ranges and categories by developing key performance indicators for both negative and positive behaviours. A practical example of the collaborative behaviours can be found in the 2012 London Olympics, where the contractual arrangements used on this project were designed to support the collaborative relationships between the main contracting parties including Olympic Delivery Authority, client and principal contractors [410]. This collaborative approach supports clearly-defined procedures to deal with unpredictable, ill-defined interfaces and changing conditions found within and between each package in this project [410].

7.4.4.4 Incentivise Shared Outcomes

The findings show that the existing contracts only allow for a temporary integration among the contracting parties rather than long-term and sustainable integration. This underlined that there is a poor integration between clients and suppliers, which can act as one of the barriers to manage the complexities of Megaprojects. Accordingly, the findings suggest the need for a contractual arrangement where various parties are jointly incentivised not in the success of the bit of the project for which they are responsible but in the success of the overall project. That is, they actually have a commercial incentive to collaborate, and that is critical. For example, if it is a railway, and the client wants capacity, the more people involved in the decision-making process, the better outputs can be achieved. Thus, the client places some incentives on meeting the overall requirements or the requirements for interfaces, and places some incentives on overall completion and meeting the overall objectives, and this allows the client to meet their objectives. Thus, in this way, when any uncertainty happens, both the client and supply chain contractors will always be directed in the direction best for the project.

The above finding is supported by a recent NAO report on problems with how the government manages its service contracts, which stated that not all Departments in the UK government have had a strategic approach to managing their supplier relationships, as well as the engagement of senior management with suppliers has not been widespread across the government [481]. The same NAO report argues that the lack of meaningful incentives for innovation can inhibit shared approaches to problem-solving and service improvement [481]. Techniques like optimised contractor involvement (OCI) or early contractor involvement (ECI) are used in the London Olympics, and the Crossrail aimed to incentivise contractors and suppliers to research and develop new ideas [188].

7.5 Proposed Approach Validation

The preceding section explained how the proposed risk management approach for managing and mitigating MCRs was developed on the basis of the information and thoughts of experts who had been involved in Megaprojects, which were provided via AGT interviews. Arguably, AGT allows for internal validity [482] because the theoretical sampling naturally leads to additional venues (interviews) as a means to validate theoretical codes, categories and dimensions of the subcategories [469]. However, the developed approach needs to be validated externally. External validity concerns the ability of research findings to explain, or occur in, similar phenomena at a general or universal level rather than being something that is unique to the particular case(s) used for the research [423]. For the current research purposes, the main objectives of the validation task are:

1. To make sure that the four elements of the proposed approach (ACT, PMO, COP and NFC) are correctly structured, and their contents and specifications are clear and complete.

2. To check the practical applicability and implementation of the four elements of the proposed approach in the real world (UK context) in the future.
3. To make sure that the four elements of the proposed approach are effective and useful to manage and/or mitigate MCRs collectively in a better way.

In order to achieve the validation objectives set in the previous section, a Delphi technique was used as explained and justified in Chapter 5 by generating the consensus opinions of Megaproject experts on the proposed approach to risk management in Megaprojects [483]. The next sections discuss and justify the process of the adopted Delphi technique.

7.5.1 Delphi Process

The adopted Delphi process in this research consisted of three rounds, as shown in Figure 7.6. Round 1 was developed to address the main objectives of the validation task, whereas round 2 was developed according to the responses from the previous round. Similar to round 2, round 3 was developed based on implications of the previous round. The consensus about the final design and structure of the proposals for the MCR mitigation measures was reached after three iterations. Each round is discussed and justified in the following sections.

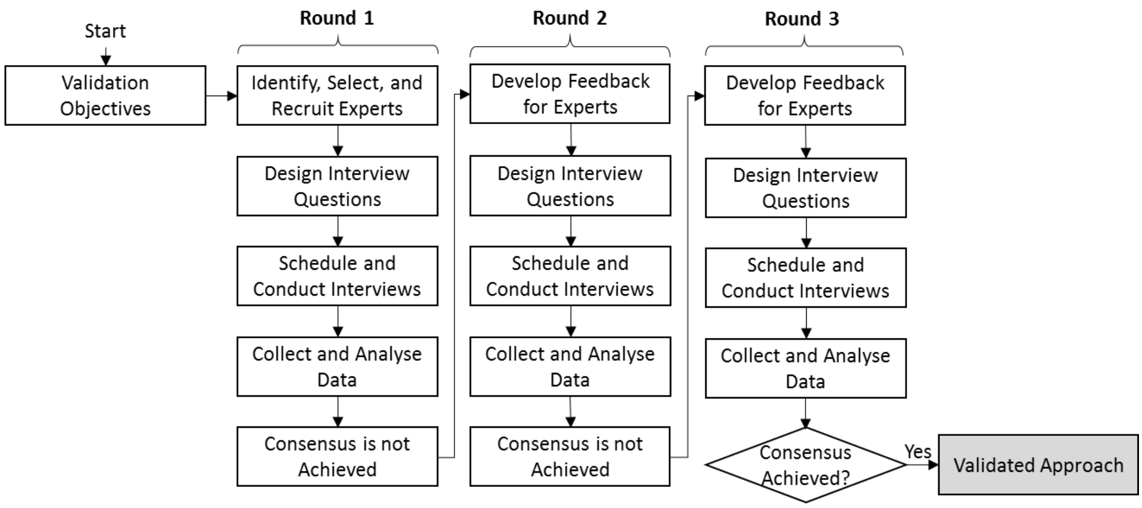

Figure 7-6 Adopted Delphi Validation Process

7.5.1.1 Round 1

The focus of this round was to seek the experts' opinions and gather their thoughts to make sure that the four elements (ACT, PMO, COP and NFC) of the proposed approach to MCR mitigation measures are correctly structured, and their contents and specifications are clear and complete. Furthermore, the focus was on making sure that the proposed approach is effective and useful to manage and/or mitigate MCRs collectively in a better way. It was also intended to check the practical implementation of the proposed approach in the UK context.

Therefore, the Delphi Guide of Round 1 was developed, which outlines the original design of the four mitigation measures proposals (ACT, PMO, COP and NFC) supported with a set of questions for each mitigation measure, as shown in Appendix M. Once the Delphi panel experts agreed to attend semi-structured interviews, this guide was sent to them in advance to give them sufficient time to gather their thoughts about the MCR mitigation measures proposals.

Once the experts were happy to proceed with the interview, a brief introduction about the research was given to them in order to 'warm-up' the interview. The experts were also briefly told the purpose of the Delphi validation sessions and the objectives of the semi-structured interview for this round in particular. A brief explanation and illustration of each mitigation proposal were then provided and outlined to the experts in order to make sure that they understand the terminologies used in each diagram.

The experts then were asked to answer the validation questions provided in the Delphi Guide for Round 1. The experts were given the opportunity to highlight and indicate if there were any missing elements in the MCR mitigation measures proposals and to suggest and provide new insights and introduce new ideas, if they had any, for improvement.

All of the interviews in this round were audio-recorded and then transcribed, as presented and shown in Appendix P. These transcriptions were then analysed through a microanalysis process, as discussed in Section 7.5.3. The findings of this round were then summarised and are provided in Section 7.5.4.1. At the end of this round, the findings were reflected in the original design of the MCR mitigation measures proposals. Accordingly, a modified version of these proposals was developed with a new set of questions to be sent to the panel of experts for a second round to check the degree of consensus among them.

7.5.1.2 Round 2

The main purpose of round 2 was to begin the process of building the consensus among the experts regarding the design and structure of the modified version of the MCR mitigation measures proposals which had resulted from round 1 [484]. Therefore, this round started by showing the experts the Delphi Guide of Round 2, which involves the modified version of the MCR mitigation measures proposals supported with a new set of questions, as shown in Appendix N. This guide enabled the experts to see the anonymous modifications and suggestions provided by the whole panel of experts in round 1 to the original design for the MCR mitigation measures proposals.

The interviews in this round started with a brief introduction about the focus of the round, which is to reach a good level of consensus on the modified version of the MCR mitigation measures proposals. Then, a brief explanation and illustration about the modifications and adjustments (highlighted in red) of each mitigation measure proposal were outlined, explained and justified briefly to the experts in order to make sure that they understood it.

The experts were then given the opportunity to check if their responses in round 1 definitely reflected their suggestions and thoughts. They were also given the opportunity to evaluate the extent to which they agreed or disagreed with the emerging modifications made to the original proposal design, so they could adjust and reconsider their answers with providing justifications accordingly. Again, the experts were asked to state whether the latest version required any more modification, for further improvement.

Again, similar data collection protocol and analysis process were conducted based on all the responses from round 2. The transcription of this round then presented in Appendix P. The findings of this round were then summarised and are provided in Section 7.5.4.2. These findings suggested slight alterations, which were reflected in the modified version of the proposals. Accordingly, a second modified version of the proposals was developed with a new set of questions to be sent to the panel of experts for a third round to check the degree of consensus among them.

7.5.1.3 Round 3

The previous round shows that, although the consensus among the experts was not reached about the modified version of the MCR mitigation measures proposals, only slight alternations were suggested and reflected upon. However, it was still necessary to conduct another round to try and obtain a higher percentage of consensus among the experts. Accordingly, the questions for round 3 were developed and then distributed to each expert, as shown in Appendix O. Again, these participants were given the opportunity to reconsider and adjust their feedback if needed. According to their feedback, the consensus among the majority of the experts regarding the structure and design of the latest modified version was reached. Therefore, in this research study, round 3 of the Delphi expert survey is the final one.

7.5.2 Delphi Panel Selection Process

The success of the Delphi technique principally depends on the careful selection of the panel of experts [483, 485]. Arguably, the key criteria to select this panel in the Delphi technique are work experience, availability and accessibility [483, 485]. Therefore, in order to validate the proposed approach of MCR mitigation measures proposals (ACT, PMO, COP and NFC), there is a need to identify, approach and recruit experts with extensive experience, knowledge and professional standing in planning and delivering Megaprojects in the UK context. These experts should also have had/have major risk responsibilities in Megaprojects as they will then be more capable of answering questions and providing in-depth information on managing and mitigating MCRs in a better way.

In the current research, the three-step process is proposed in accordance with the Ethical Approval Requirement of the University of Leeds, as shown in Figure 7.7. First, the experts were identified using random sampling [486], and then each expert who meets the selection criteria was selected accordingly. Accordingly, any expert that did not meet the selection criteria was excluded from the Delphi panel. Once the potential experts were identified, an invitation letter to take part in the research was sent to them via email. Any expert who did not accept the invitation or did not respond to the invitation email within one week was excluded from the Delphi panel. The selection process continued until the minimum number of experts required for the panel was reached.

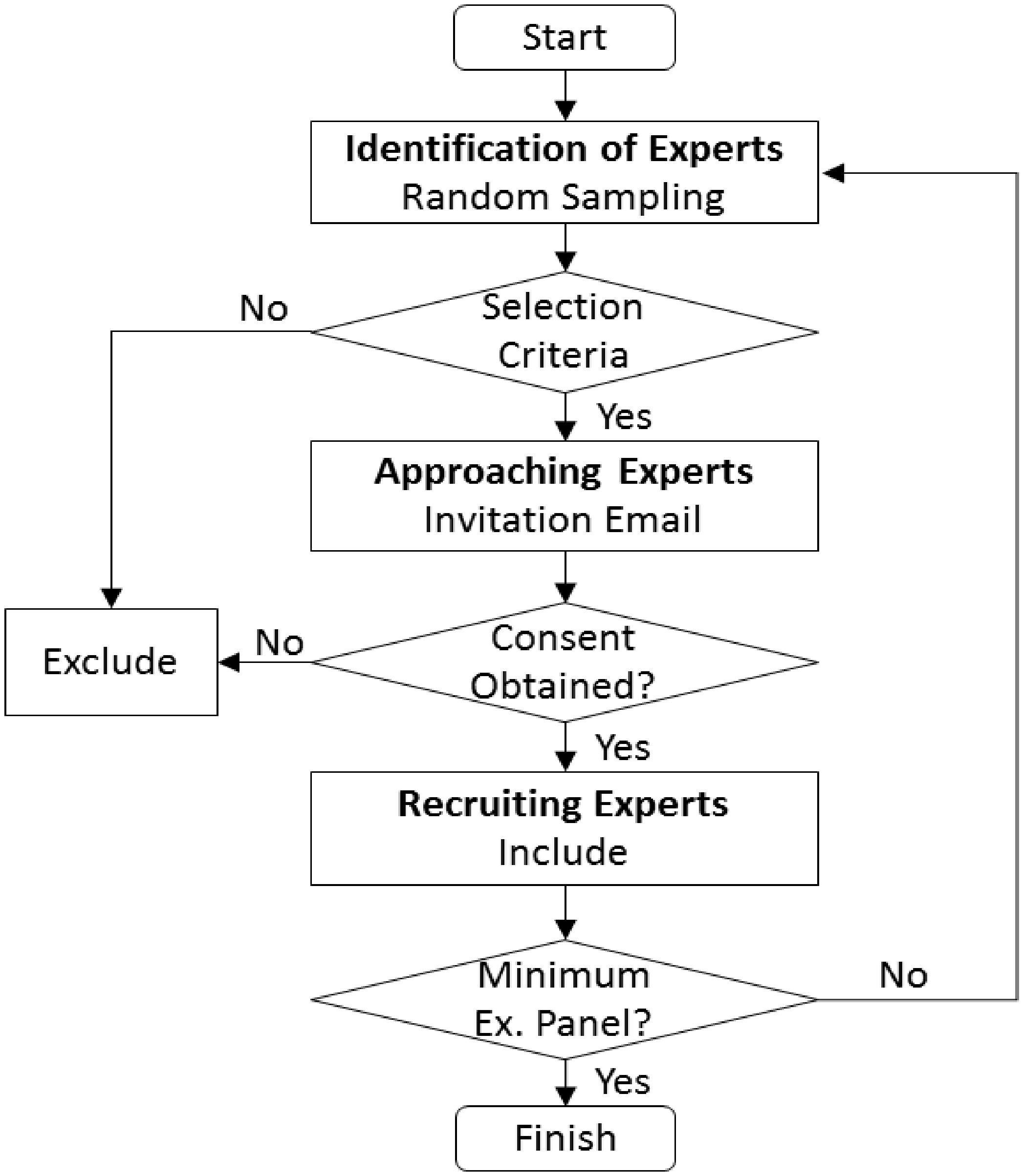

Figure 7-7 Delphi Panel Experts Selection Process

As regards the size of this panel, Hallowell and Gambatese [483] argued that a sufficient number of panellists should be selected at the start of the process to ensure a qualified panel at the end of the study, assuming some will not complete each round. The current study involved eight expert panellists, as suggested by Hallowell and Gambatese [483]. The minimum number of eight was used as a threshold to identify, approach and recruit the qualified experts, as shown in Figure 7.7. The profiles of these experts are listed in Table 7.1.

Table 7-1 Profiles of the Delphi Panel Experts

ID	Background	Location
EP1	Senior Policy and Strategy Officer at a governmental authority in the UK with more than 30 years' experience in advising and forming transport policies.	UK
EP2	CEO at an underground Megaproject in the UK with more than 37 years' experience in managing, directing and delivering Megaprojects in the UK and globally.	UK
EP3	Senior Director of Enterprise PMO in a government-owned company in rail infrastructure and asset management with more than 25 years' experience in planning, managing, and delivering Megaprojects in the UK.	UK
EP4	Head of Learning Legacy and Stakeholder Engagement at an underground Megaproject in the UK with more than 20 years' experience in managing and delivering Megaprojects in the UK.	UK
EP5	Senior Executive Director at a nuclear decommissioning Site Licence Company (SLC) owned by the UK government with more than 30 years' experience in managing and delivering Megaprojects in the UK and globally.	UK
EP6	Senior Development Director in a complex infrastructure programme in a government-owned company with more than 20 years' experience in directing Megaprojects and similar Programmes in the UK.	UK
EP7	Senior Director of Project Profession and Standards in governmental authority in the UK with more than 40 years' experience in senior management and leading Megaprojects and Programmes in the UK.	UK
EP8	Senior Director of Design in a Megaproject airport in the UK with more than 30 years' experience in designing and directing Megaprojects and similar Programmes in the UK and globally.	UK

7.5.3 Delphi Data Analysis

The analysis of data from the Delphi technique was an ongoing process, taking place at the conclusion of each round. The process adopted to analyse data and measure consensus in this research consists of a number of activities for each round, as shown in Figure 7.8.

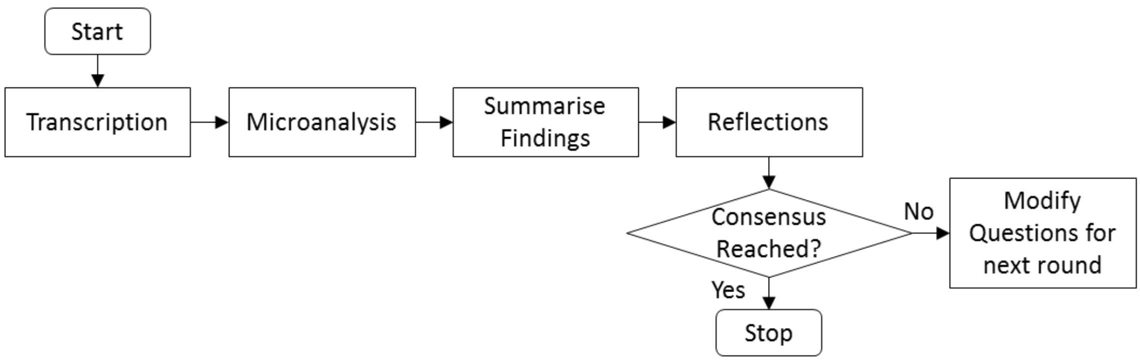

Figure 7-8 Delphi Data Analysis Process

Once all the interviews were completed for a particular round, the researcher listened to the recording, read the interview notes (for those without recording permission), or read the notes written by the interviewee (for those who provide extra written information). The recorded interview was then transcribed verbatim to represent the dynamic nature of the conversation. The transcriptions of all interviews were read carefully to obtain a general sense of the information and reflect on that data's overall meaning as shown in Appendix P. The response rate of Megaprojects experts' panel in the three rounds were also provided in Appendix P.

Then, the transcriptions of all the interviews were analysed using a similar microanalysis process to that used in the AGT sessions [472], which consists of steps including a detailed line-by-line analysis, labelling, categorising and identifying relationships. Due to the small interview sample, a simple manual coding technique was used for the microanalysis process, which may be sufficient for this purpose [185]. Therefore, highlighter pens and marker pens were used in order to code the data manually.

During the microanalysis process, major points and important data were marked down and highlighted for each transcript to identify key suggestions. The identified suggestions were labelled and coded by segmenting the data through making sense of individual fragments of information. All suggestions and opinions of the participants from each round were then summarised and organised in tables, based on which some modifications were made to the original design of the MCR mitigation proposals.

Once these modifications were made, a test was made at each round to check consensus about the experts'' suggestions for each round [185]. However, according to Hallowell and Gambatese [483], one of the more difficult aspects of the Delphi process is using an appropriate method to measure consensus. Hallowell and Gambatese recognised that there is a lack of guidance in the literature that describes the level of variance that represents a consensus in the Delphi method.

The current research followed the principle of theoretical saturation, when the collected data provide no new information about a particular topic, as suggested by Skulmoski *et al.* [484]. Thus, if a consensus was reached, then the process would be stopped. Otherwise, a new set of questions which would be designed in accordance with the modification suggestions would be sent to the panel of experts for the next round alongside the modified version of the MCR mitigation proposals.

7.5.4 Delphi Findings

The findings of the three rounds of Delphi technique are presented and structured in accordance with the sequence of questions in each round, which basically follows the sequence of ACT, PMO, COP and NFC, as presented in the following sections.

7.5.4.1 Round 1

During round 1, qualitative feedback was captured from the experts to the questions in Appendix M. The results of round 1 indicated that most of the experts were in agreement about the principle of developing and legislating a specific ACT for Megaprojects. They also appreciated the concept of establishing a legislative exemption mechanism that would isolate Megaprojects from externalities. One expert stated:

> *"I accept the principle, and I can see the point of isolating Megaprojects from externalities, and I agree with… but you need more considerations about what are the funding sources to the project, i.e. whether it is a government-funded project, privately funded project, or is it like a utility bill." EP2*

However, some experts argued and advised that this mechanism should include some democratic involvement that would improve the outputs of the consultation session. One expert stated:

> *"What I suggest is you might need to include in your mechanism something like citizen assembly, which fashionably talks about major issues like Brexit, climate change and other things." EP1*

The results of round 1 indicated that the majority of the experts were also in agreement about the proposed PMO-based governance model. However, a few experts diagnosed some missing elements in the input process to develop the

COP. These experts argued that no consideration is given to the role of devolved authorities and administration in the new governance structure. For example, one expert stated:

> *"I think what is missing in the PMO governance framework is the input from devolved authorities and administrations, by which I mean Scotland, Wales or North Ireland, where appropriate." EP8*

With respect the COP, most of the experts who agreed with the concept with PMO were also in agreement about the rationale of developing and mandating a dynamic COP for Megaprojects. One expert stated:

> *"Although the code of practice will be different from project to project, the idea of re-inventing and updating this code every time you come across a new project is good and make sense." EP2*

However, some experts suggested that the COP development process lacked a feedback mechanism on the content of such COP. These experts suggested that there is a need for an endorsement mechanism form professional institutions to provide feedback on the COP and report this feedback to the PMO to consider. One expert stated:

> *"I really think you might need an endorsement here with your code development process... you want somebody to act as a kind of external consultant to make sure that your code of practice really reflects the cutting-edge practices and to fill gaps if any." EP5*

The main suggestions and recommendations made by the experts in this round with respect to all the MCR mitigation measures proposals (ACT, PMO, COP, and NFC) are summarised in Table 7.2. To address these suggestions, actions were drawn up, as listed in the same Table 7.2.

Table 7-2 Results Summary of Delphi Round 1 with Response Actions

ID	Experts' Suggestions and Recommendations	Response Actions
ACT	• There is a need for a democratic involvement process like a citizen assembly at some stages in the legislative exemption mechanism. • The outputs of the legislative exemption mechanism need to be	• The term "citizen assembly" is added into the consultation box in the same mechanism. • A "parliamentary approval" decision point is made to the legislative exemption process supported with a new arrow to the consultation box.

ID	Experts' Suggestions and Recommendations	Response Actions
	approved by parliament to be applied. • Megaprojects need to conduct more consultations if the exemption proposal is not secured. • The legislative exemption mechanism needs to consider both the planning permission root and financial arrangement of Megaprojects. A governmental support package is needed for privately financed Megaprojects.	• A new line is drawn from the decision point and connected to the consultation box instead of the finalising box with a statement "re-consultation and revising relief measures". • A new statement, "governmental support package for privately funded Megaprojects", is added to the output box.
PMO	• There is a need for an integration between the devolved authorities administration and the PMO in the proposed governance system. • There is a need for a direct feedback link between from the IPA to the PMO in order to improve the strategic oversight process and make it more dynamic. • The NAO needs to be outside the COP, i.e. it should keep making its principle auditing process	• New Bullet points NIC, HM Treasury, Devolved Authorities, Local Authorities are added to the "Data from Different Sources" box. • A new arrow is drawn from the IPA box and linked to the PMO box supported with the statement "Direct Reporting". • The COP box is resized to exclude both the NAO and the IPA as suggested.
COP	• There is a need for endorsement mechanism form professional and institutions to check and evaluate the COP in order to ensure no increased risk of delivery • The PMO needs to consider both the planning permission root and financial arrangements of Megaprojects and reflect these into the COP. • The PMO needs to has some input from the devolved authorities administration to develop this COP.	• A new box titled "professional Institutions and legal advisors" is drawn in the COP development process diagram and linked with COP with two statements "endorsement" and "legal advice" supported with the statement "reflected" . • Two statements "planning permission and financial arrangement" are added within the ACT principles box. • A new statement "devolved authorities" is added to the "Data from Different Sources" box.
NFC	• There is a need for rolling-wave planning mechanism to be accommodated within the procurement strategy. • There is a need to shift from prescriptive based contract into a performance-based contract. • The contracting parties need to have an open-minded mentality to accept and manage changes in Megaprojects • There is a need to create a partnership culture in order to achieve high collaboration	• A new statement "rolling-wave planning" is added to the original statement "Concurrent Procurement Approach". • The original statement "Incentive Scheme" is replaced with a new statement "performance-based contract". • The original statement "Package level and Contract Level " is replaced with a new statement "open-minded mentality". • The original statement "Collaborative Workshops" is replaced with a new statement "partnership culture".

By taking into consideration the experts' suggestions and recommendations listed in Table 7.2, modifications were made to the original design of MCRs mitigation measures proposals accordingly. For example, changes were made to the initial design of the legislative exemption mechanism by creating a parliamentary approval decision point to the exemption process. The modified version of MCRs mitigation measures proposals and diagrams with clear indications to the main modifications (coloured by red) were then packed into Delphi Guide of Round 2, which then was emailed to the experts' panel for round 2 to measure censuses.

7.5.4.2 Round 2

This round sought to ascertain the degree to which consensus was possible among the experts on a modified version of MCR mitigation measures proposals shown in Appendix N. Therefore, all the experts were given the opportunity to express their comments, suggestions and any disagreement with the anonymous suggestions and modifications that emerged from round 1 and which are presented in Appendix N. Accordingly, they were given the opportunity to revise, or reaffirm, their initial responses made in round 1 in view of the modified version of the MCR mitigation measures proposals. The results of this round showed that a good agreement was reached among the experts on most of the suggestions and recommendations. Accordingly, the majority of the experts reconfirmed their responses while some of them adjusted their previous responses in light of the anonymous suggestions.

Although there was a good alignment among all the experts, additional minor recommendations were made in this round, which are summarised in Table 7.3. Again, to address these suggestions, actions were also made, as listed in the same Table 7.3. Taking into consideration these minor recommendations, further amendments were made to the modified version of the MCR mitigation measures proposals. As a result, a second modified version of the proposals was developed with a new set of questions, as shown in Appendix O. The latest version of the proposals and diagrams with clear indications to the main modifications (coloured in red) were then packed into the Delphi Guide of Round 3, which was then emailed to the panel of experts for round 3 to measure consensus.

Table 7-3 Results Summary of Delphi Round 2 with Response Actions

ID	Experts' Suggestions and Recommendations	Response Actions
ACT	• The preparation phase should be heavily guided by value for money analysis, not just a list of legislation. • The statement "List of Response Actions" is unclear and needs to be more comprehensive.	• A new statement, "supported and rationalised with value for money analysis", was added to the preparation box. • The statement "List of Response Actions" was changed to "List of response measures and actions to meet requirements of affected bodies".
PMO	• Megaprojects and Programmes need to provide and report PMO with their performance outputs as early as possible to allow POM to measure their compliance with COP.	• A new arrow was drawn from the PMO box to the COP with a statement on "development" to indicate that the PMO is the developer of this COP. Further, a new arrow was drawn from the PMO box down to the Megaprojects and Programmes box to reflect the direct contribution of strategic oversight. Moreover, a new arrow was drawn from the Megaprojects and Programmes box top to the PMO with a new statement, "Performance Reporting".
COP	• There is no indication of the endorsement and legal feedback in the diagram. • There is no indication of the PMO consideration of the planning permission root and financial arrangements of Megaprojects in the diagram.	• A new dash-line was drawn from the PMO and connected to the "considerations" box, and the "considerations" statement was repositioned to be associated with the new dash-line. • A new arrow was drawn from the "Professional Institutions and Legal Advisors" box to the PMO box supported with "Feedback" statement.
NFC	• Greater innovation is needed for performance-based contract systems. • Adaptability is also necessary to fill the gap between performance and descriptive specifications. • Accountability is needed to ensure that risk is allocated and/or shared appropriately. • Transparency is also needed to ensure there is no hidden agenda exploiting contract conditions.	• A new line was drawn from the "Open Minded Mentality" and connected to the "Performance-Based Contract" supported with "Innovation" statement. • A new line is drawn from "Performance-Based Contract" and connected to "Concurrent Procurement Approach + Rolling Waving Planning" supported with "Adaptability" statement. • A new line is drawn from the "Concurrent Procurement Approach + Rolling Waving Planning" and connected to "Partnership Culture" supported with "Accountability" statement. • A new line is drawn from "Partnership Culture" and connected to the "Open Minded Mentality" supported with "Transparency" statement.

7.5.4.3 Round 3

This round was developed according to the minor recommendations that were made anonymously by the experts in round 2. Similar to round 2, in round 3 the experts were given the opportunity to revise or confirm their responses made in the previous round (if any) in view of the modifications made and presented in Appendix O. The results of round 3 showed that there were no further notes and recommendations to the latest modified version of the MCR mitigation measures proposals presented in Appendix O. This underlines that a high level of agreement was reached among the experts and hence gives confidence in the validation task and provides a reason not to go for another round. Therefore, in this research study, the process of Delphi validation is stopped at round 3 (the final one) as the researcher considered that a consensus had been achieved.

7.5.5 Delphi Implications and Reflection

The previous sections present the results of the three rounds of the Delphi validation process. These results reflect the views and opinions of the Delphi experts' panel on the validity of the original design of the four elements of the MCR mitigation measures proposals (ACT, PMO, COP and NFC). The experts' suggestions and recommendations in the three rounds were considered by the researcher and are reflected in the final design of the proposals. The following sections aim to present and justify the main alterations of each mitigation measure proposal.

7.5.5.1 ACT

The Delphi results show that the legislative exemption mechanism has a number of significant modifications, as shown in Figure 7.9. The first adjustment was about including a citizen assembly into the consultation phase, as recommended by most of the experts, in order to reduce the risk of non-violent direct actions against such Megaprojects. The other adjustment was about creating a parliamentary approval decision point in the exemption process, as suggested by the experts. The experts justified this by arguing that there is a constitutional issue with the UK context in particular, where a future parliament can rescind a law passed by a previous one, which seems to be the opposite of what this states. Although the parliament approval could be a time-consuming process, it will reduce that constitutional risk.

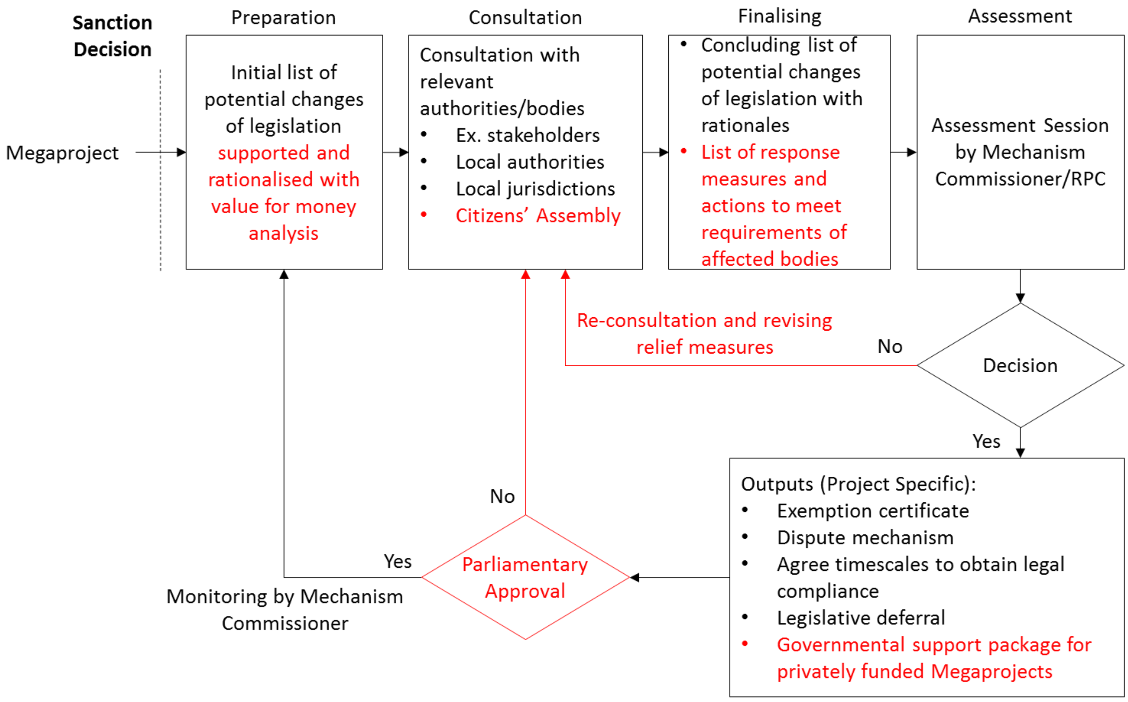

Figure 7-9 Legislative Changes Exemption Mechanism (Modified)

It can be seen from Figure 7.9 that, if an exemption proposal is not secured by the mechanism commissioner, the legislative exemption mechanism requires more consultation sessions to be held with the relevant authorities. The experts justified this by arguing it is not enough to change the action plans concluded by the project as replacements to meet the relevant authorities' requirements. Finally, the experts also suggested that one of the limitations in this legislative exemption mechanism is the lack of consideration to the planning and financial arrangements of Megaprojects. They argued that public Megaprojects would obtain more benefits from this mechanism compared with privately financed Megaprojects. Accordingly, they suggested that a governmental support package should be provided for privately funded Megaprojects, to bear some risks and externalities.

7.5.5.2 PMO

The implications of the Delphi results have changed the initial design of the PMO-based governance model and improved it into a more focused version, as presented in Figure 7.10. The first change to this latest version related to providing some input from the devolved authorities and administrations, especially those that are associated with Scotland and Wales, where appropriate.

One of the experts mentioned the case of HS2 as a practical example, which is coming to Birmingham at the same time as that city's main preparation for the Commonwealth Games, and if that Megaproject does not liaise effectively with the combined authorities and local devolved authorities, it could lose a lot of money. Therefore, these experts suggest that there is a need for some kind of legal duty to cooperate with devolved authorities and ministers in various administrations to reduce the conflict risk.

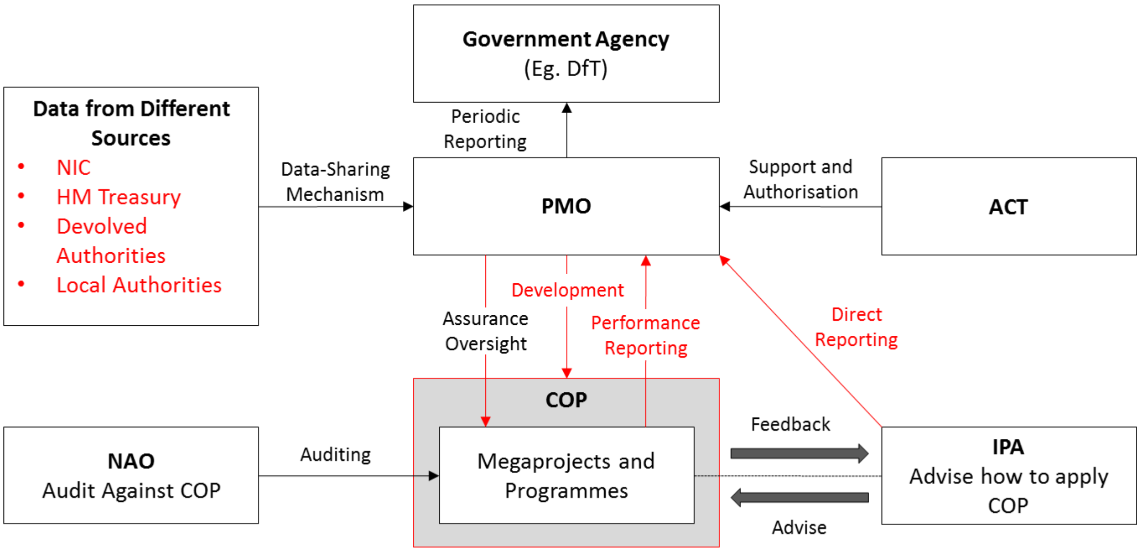

Figure 7-10 Megaproject Governance Model (Modified)

In addition to the above, the original version of the PMO governance model has been modified by providing a direct communication mechanism between the IPA and the PMO, as shown in Figure 7.10. The rationale behind this decision was based on the views of some of the experts who argued that, in order to develop a dynamic COP, the IPA should report the PMO directly with best practices as they emerged. Some experts argued that, if there is no link between the IPA and the PMO, Megaprojects can stop the PMO from hearing anything from the IPA. The last modification was about the role of the NAO in the process, which was suggested by the experts to be outside the COP development process. The experts argued that, despite the fact that the NAO should not be a part of the PMO governance structure, it obviously should be cited.

7.5.5.3 COP

The Delphi results show that the COP development process has a number of significant modifications, as shown in Figure 7.11. The first modification was made to provide some endorsement mechanism from professional and legal institutions to check and evaluate the COP in order to ensure there is no increased risk of delivery. Some of the experts justified that suggestion by arguing that there is no process by which Megaprojects can complain about the content of such a COP or provide some feedback to improve it.

Further adjustment was made to the development process by taking into account the planning root of Megaprojects in the UK context, i.e. whether a Megaproject is authorised or licensed to be delivered by a Hybrid Bill, Development Consent Order (DCO), Network Rail's Development Rights, etc., as well as the financial arrangement model, i.e. whether is it a publicly, privately or PPP funded Megaproject. These experts justified this suggestion by saying that, if these considerations are not taken into consideration, the process of developing and mandating this COP could get complicated.

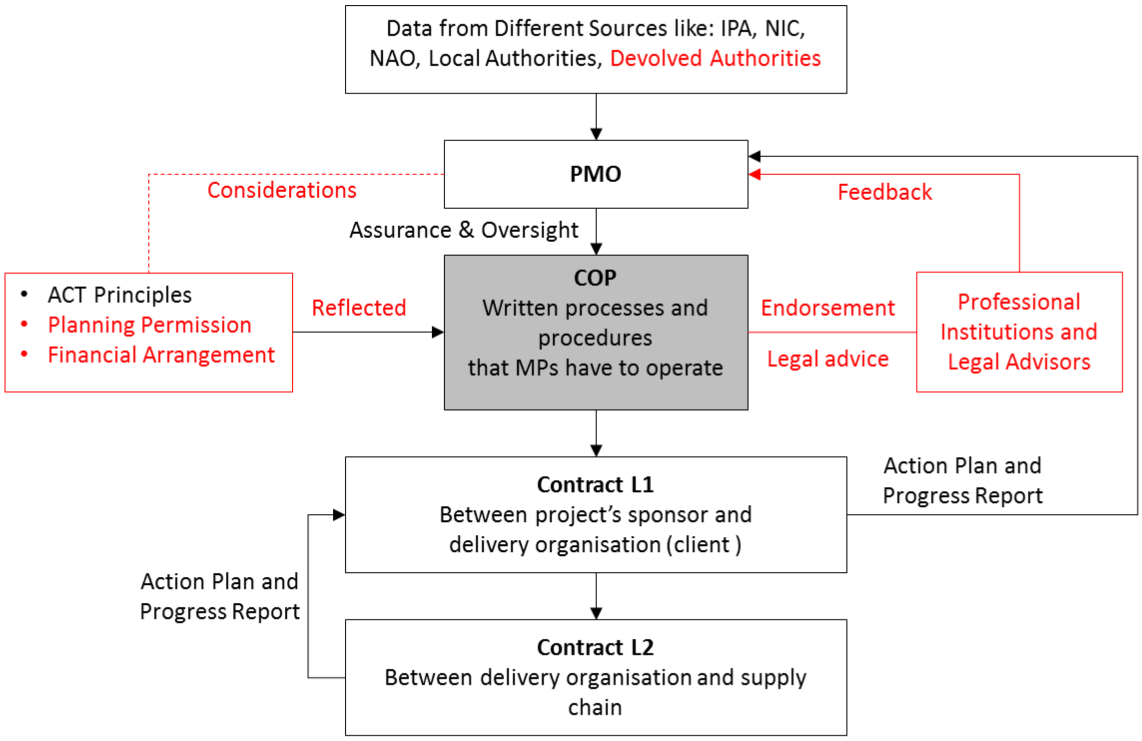

Figure 7-11 COP Development Process (Modified)

7.5.5.4 NFC

The Delphi results show that the NFC has a number of significant modifications, as shown in Figure 7.12. The first modification is about changing the mind-sets of the contracting parties to be more open to adapt to and accept changes. The experts justified this by arguing that the main purpose of the contract is to reflect the requirements and the mind-sets of the contracting parties and their advisors at different organisational levels (Corporate, SBU and Project). These advisors are normally lawyers, bankers and consultants, who have insufficient understanding of the scale and complexity of Megaprojects. The second modification is about using a rolling-wave planning mechanism in order to support the concurrent procurement strategy. Such a mechanism allows for periodic planning, which in turn helps to reduce and minimise the likely interfaces. The experts justified this by arguing that it is quite challenging to produce a detailed schedule and contract for Megaprojects simply because they have very long time frames, which are very often associated with turbulence and change.

The other modification is to shift from using a prescriptive-descriptive-based contract with lots of details to a performance-based contract. The Delphi experts argued that focusing on the performance in Megaproject contracts can incentivise both the delivery organisation and its suppliers to look at the project as a whole. They also added that such a concept would also probably reduce the level of complexity in Megaprojects if everyone in the project is aware and clear about the definition of the outcomes. The last modification is about creating unity and a partnership culture in the process of project delivery, where everyone has aligned interests. The rationale behind this suggestion is justified by the experts by arguing that such a culture is essential for complex systems like Megaprojects as they involve lots of stakeholders with conflicting interests. They also argued that a partnership culture could create a coherent delivery process rather than one that is fragmented among the involved parties and players.

The Delphi validation results show that, in addition to these modifications, the NFC needs to consider four aspects to be more comprehensive: Innovation, Adaptability, Transparency and Accountability. The experts suggested that greater innovation is needed to facilitate the movement from descriptive contract systems into performance-based contract systems. Adaptability is also necessary to link between the delivery performance specifications and the detailed requirements of periodic planning. Accountability is also necessary to ensure that risk is allocated and/or shared appropriately among the contracting parties, especially within the partnership culture. Lastly, transparency in all contracting parties is also needed to ensure that there is no hidden agenda exploiting contract conditions.

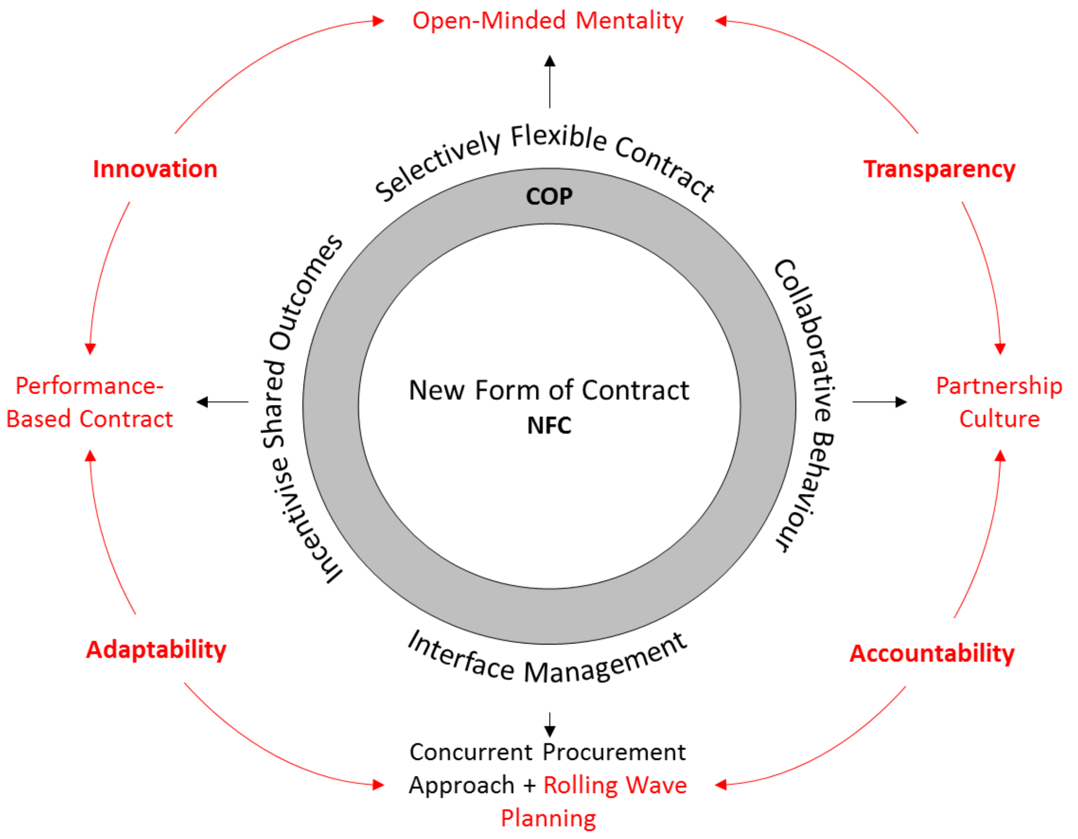

Figure 7-12 NFC Elements (Modified)

7.6 Summary

This chapter has presented a new approach for systematic identification, management and mitigation of MCRs within the context of the UK. The main objectives of the proposed approach have been provided in this chapter. The process of approach design and development was explained in detail, and the shaping of the approach components was also discussed. The empirical findings of the AGT interviews have been discussed, explained and justified by comparing them with the literature and existing practices. This chapter has then presented the results obtained from three rounds of a Delphi validation exercise with a panel of experts in Megaprojects to ensure that the proposed approach is complete, correct, practical and applicable. The validation findings revealed that a consensus was reached about the validity of the four components of the proposed approach: ACT, PMO, COP and NFC.

Chapter 8 Discussion

8.1 Introduction

This chapter critically discusses the main findings arising from this research study in the UK context and their implications for theory and practice. It also discusses and explains the implementation of the proposed approach in managing and mitigating MCRs. This chapter consists of five sections, including this introduction. Sections 8.2 provides a critical review of the elements of the proposed approach in the context of current UK practice. Section 8.3 discusses in detail how MCRs could potentially be managed and mitigated through the validated mitigation measures proposals (ACT, PMO, COP and NFC). Section 8.4 discusses the implications of the research findings in theory and practice. Lastly, Section 8.5 summarises the chapter.

8.2 Critical Appraisal of the Proposed Approach in the UK Systems

8.2.1 Critical Appraisal of ACT

The difference between the proposed ACT and existing statutory instruments – The literature shows that the existing Acts of Parliament and statutory instruments in the UK Parliamentary System are mainly enacted to acquire permission for planning and developing different kinds of Infrastructure projects. There are four ways to acquire permission for planning projects in the UK [487]. First, the Hybrid Bill procedure through the UK Parliament [236]. Second, the Development Consent Orders (DCOs) under the Planning Act 2008 [338]. Third, the Transport and Works Act Order (TWAOs) under the Transport and Works Act 1992 [488]. Fourth, the conventional Planning Permission System under the Town and Country Planning (TCPA) Act 1990 [336]. Hybrid Bills often concern projects of national significance, examples being the Channel Tunnel Rail Link (HS1), High Speed 2 (HS2) and Crossrail (Elizabeth Line) [487]. Megaprojects also could be promoted under DCOs if the scheme satisfies the criteria of being a Nationally Significant Infrastructure Project (NSIP), such as major rail, transport, road, energy, and water and waste projects [338]. The HPC project is an example of an NSIP that required a DCO in order to be authorised. A decision on the application for a Development Consent Order for HPC New Nuclear Power Station was taken on 19 March 2013 and has now been issued [489]. While both Hybrid Bills and DCOs are used to promote nationally significant infrastructure, the key practical difference between them is that Hybrid Bills are used where the government is the promoter, and orders tend to be used by private organisations, although public agencies occasionally use them as well. TWAOs are typically granted for railway, tramway or harbour infrastructure, with a particular focus on light rail systems in urban areas [487]. And, finally, the Town and Country Planning Act 1990 (TCPA) can be used for planning permission for works which do not fall under the Planning Act 2008 [336]. The above statutory instruments underline that these could primarily manage and/or mitigate risks associated with land acquisition, expropriation, or nationalisation [490].

However, the features of Megaprojects such as the scale of complexity, long life cycle, and the significant impact on global aspects make them less adaptable to non-commercial risks such as frequent-unexpected legislative changes [491]. The lack of adaptability of Megaprojects to such legislative changes could negatively affect the delivery performance of this sort of project [492]. Therefore, the current study suggests the need for a new Act of Parliament to accommodate provisions and mechanisms, allowing compensation to cover the costs associated with non-commercial risks such as legislation changes [129]. A similar concept of such an Act can be found in other countries like Australia, which has the Major Transport Projects Facilitation Act No. 56 of 2009 to provide compensation for major transport projects for some extreme events [493]. The proposed ACT in the current study can provide government guarantees to adjust tariffs or extend concessions if legalisation changes occur [23]. The proposed ACT could also provide a legislative changes exemption mechanism to increase the adaptability of Megaprojects to legislative and policies changes. This mechanism allows a Megaproject's sponsors and clients to seek exemption from the legislative changes, where exemption conditions could be set by high commissioning authorities (mechanism commissioner). Therefore, it can be argued that the proposed ACT can be considered a fundamental measure that can reduce the impact and probability of the adaptability to legislation changes (MCR1) across all Megaprojects.

The implications of enacting a single (bespoke) or generic Act of Parliament – The literature shows that statutory instruments are enacted for other different purposes. Some countries, such as the UAE, France, Poland and Mexico, have enacted statutory instruments such as Public-Private Partnership (PPP) laws and regulations [342] to establish a clear institutional framework for developing, procuring, reviewing and implementing Megaprojects under PPP schemes [234]. The differences between generic enactments like PPP laws and specific enactment like HS2 Act 2017 include the scope of application, where the former can be applied to all projects and permanently, while the latter can be only enacted to a particular single and project temporarily [494]. Therefore, the potential challenge that could face the enforcement of the proposed ACT is the interpretation of the ACT's provisions in different Megaproject types and contexts. The uniqueness of Megaprojects, which results from the distinctive social, environmental and economic requirements of each Megaproject [81], has implications that there is no common or standard terminology to describe similar concepts across all Megaprojects [35]. The lack of common terminology can generate inaccuracy and inconsistency in the legislation process, which eventually can cause confusion and lead to unexpected consequences like the risk of lack communication. Further, the lack of common terminology can also complicate compliance, thus increasing the risk of compliance breaches. Therefore, the proposed ACT for Megaprojects should be enacted for all Megaprojects and only Megaprojects, irrespective of what they are and where they are. Legislating a generic Act of Parliament for Megaprojects rather than a single (bespoke) Act of Parliament has implications for savings in time, efforts, resources and money.

The implications of the proposed Act of Parliament on existing health and safety legislation – The proposed ACT of Megaprojects if enacted will have implications on environmental legislations as well as health and safety legislation. Examples of these legislations include but are not limited to the Health and Safety at Work etc. Act 1974, Health and Safety (Offences) Act 2008, Environmental Protection Act 1990, Control of Pollution Act 1974, Climate Change Act 2008, Planning and Energy Act 2008, Energy Act 2020, Planning (Listed Buildings and Conservation Areas) Act 1990, National Parks and Access to the Countryside Act 1949, Ancient Monuments and Archaeological Areas Act 1979, and Countryside and Rights of Way Act 2000 [236]. These legislations may involve provisions that could interfere with the provisions of the proposed ACT, especially in terms of the legalisation exemption mechanism. For example, the Control of Pollution Act (CoPA) 1974, Chapter 40 Part III authorises local authorities to control noise and vibration from construction sites and other similar works [495]. These powers may be periodically exercised either before works start or after they have started. These provisions could interfere directly with the provisions of the proposed ACT for Megaprojects, especially those associated with the legislations exemption mechanism. This is supported by the Office of the Parliamentary Counsel [324], who argued that the interconnection between various laws, their geographical scope and their application, may not be explicit or may be inconsistent. Therefore, there is a need for consistency between the proposed ACT with other relevant legislation and statutory instruments to avoid confusion [496]. In fact, appropriate amendments and changes should be made to all potentially conflicting legislations' contradictions in a similar way when legislating modern concession laws [477]. Such contradictory legislations can lead to serious interface risks and confusion, and have significant implications for the value for money aspect of Megaprojects.

Practical challenges associated with enacting the proposed Act of Parliament – While no study is free of limitations, the proposed ACT has a number of challenges when it is applied to the UK context. Among these challenges is the diversity of financial models of Megaprojects, i.e. whether a Megaproject is funded by the public sector, like the 2012 Olympics programme and Crossrail [6], the private sector, such as Thames Tideway Tunnels and Hinkley Point C (HPC) [344, 370], or by a PPP, such as the Channel Tunnel (HS1) [497]. These funding models explain the variety of the consent and planning procedures for Megaprojects in the UK that have been explained earlier of this section. Therefore, legislators need to take into account the diversity of financial models and accommodate statutory provisions to clarify and define threshold criteria of Megaprojects that need to be considered under the proposed ACT.

Further, owing to the extremely complex nature of Megaprojects in both technical and organisational aspects [498], legislating a specific or generic Act for Megaprojects can be an extremely challenging process. The significant impact of Megaprojects on society, economy and environment, combined with the diversity of stakeholders with different interests in Megaprojects, can further challenge the legislation of an Act for Megaprojects. For example, although HPC is a privately funded Megaproject, it has a significant impact on the public, economic growth and environmental [286]; hence it will be beneficial to the sponsors to protect HPC under this ACT from particular policy changes. For example, if the UK government policy changes result in the shutdown of HPC, it should pay up to £22 billion as compensation to the operator organisation [286], which will eventually come from the taxpayers.

Therefore, extensive consultation and discussion with a wide range of interested parties are required before introducing the Bill for Megaprojects to Parliament [236]. This includes but is not limited to ministerial departments, non-ministerial departments, agencies and other public bodies, high-profile groups, public corporations, devolved administrations, senior practitioners in Megaprojects, professional bodies, Megaproject developing organisations, financial institutions, NGOs, and pressure groups. The consultation with these parties is an essential measure to align their expectations from the outset. In contrast, when external parties are not properly harnessed, there is a risk that gaps in the implementation plan may be missed or, when identified, may not be fully addressed [324]. In fact, the long-term effects of provisions may not be fully taken into consideration and stakeholders' interests may be overlooked or assessed in an inconsistent way [324].

Moreover, giving the fact that Megaprojects have different consent and legislation procedures for authorising their planning and development [487], careful attention and extensive discussions with different Megaproject sponsors are needed during the drafting of the Hybrid Bill for Megaprojects ACT. These discussions can help to highlight the practical barriers that could emerge during and after the legislating of the proposed ACT; hence provide resolutions to address any foreseen issue. The deliverables of these discussions may involve consideration to provide a clear threshold to define the level of significance of a Megaproject's impact in macro aspects, including social, technical, economic and environment. Such a threshold can help to define the application scope of the proposed ACT; hence address the diversity of Megaproject planning-licensing routes.

8.2.2 Critical Appraisal of PMO

The difference between the proposed PMO and the existing UK institutions – In the UK, the IPA is currently responsible for the strategic oversight by setting-up the policy agenda for the successful delivery of infrastructure and Megaprojects [499]. The IPA is also recognised as the government's centre of expertise for infrastructure and Megaprojects in the UK. Although the IPA is currently playing a critical role by providing strategic oversight to the delivery performance of Megaprojects, it also not free from limitations. A recent NAO report showed that the turnover of projects, the limited data published and the lack of systematic monitoring of whether projects had realised benefits made it difficult to conclude on trends in performance across the Portfolio [500]. The possible explanation behind this criticism is the IPA’s lack of enough regulatory power to influence the project delivery, since its tools and methods are more advisory rather than mandatory [499]. Therefore, there is a need for the proposed PMO to have regulatory power, similar to other countries around the world like Canada or the Philippines, to ensure the delivery organisations of Megaprojects in the UK comply with these bespoke best practices [224]. Such regulatory power can be provided through statutory instruments like the proposed ACT by accommodating useful provisions relating to establishing, setting-up and authorising the PMO at the national level. The ACT should clearly establish the rights to allow the PMO to have a certain level of control and authority over Megaprojects across the UK as a central authority and to set the principles, procedures, systems and best practices to plan and deliver Megaprojects.

The NAO also criticised the IPA for not providing complete data on the reasons why 302 Megaprojects have left the Portfolio and what they had delivered by the time of their departure [500]. The NAO also indicated that there is a varied picture as to whether projects have been delivered successfully after they leave the Portfolio [500]. A possible explanation behind this is that, once projects leave the Portfolio, the IPA is no longer responsible for monitoring their progress in delivering benefits, it is up to departments to provide this oversight. This reflects the lack of providing strategic oversight to all Megaprojects, including privately financed Megaprojects such as the Thames Tideway Tunnel. For example, the sponsor of Hinckley Point C is the responsible body to oversee the developer and has risks to manage [501] without reporting on these risks to the IPA. Thus, the diversity of the Megaproject planning routes limits the ability of the IPA to monitor, supervise and control the delivery performance of Megaprojects [487]. Further, it could also increase the complexity of the reporting process dramatically, especially when there is no common communication framework agreed by different Megaproject sponsors in the UK. This, in turn, probably could create multiple silos of data which cannot be readily accessed and/or shared across different Megaproject sponsors. Hence, the current research study suggests a need to move towards standardising best practices by the PMO alongside the guidelines to keep the delivery more resilient.

Thus, keeping both the PMO and IPA doing the same function could lead to technical complexity such as role ambiguity or role conflict. This means the individuals in the PMO and IPA become unclear or uncertain about their expectations within a certain role, typically their role in maintaining a strategic oversight on Megaprojects in the UK [502]. Therefore, some authors have argued that, in order to meet the strategic expectations of the senior management, it is important to have a facilitator to consult project stakeholders in order to understand their problems, needs and ideas [220]. Unfortunately, the task of aligning the expectations of Megaproject stakeholders, both internal and external, is outside the scope of the IPA, but it is located within the client organisation of Megaprojects like HS2 Ltd or Crossrail. This underlines that the IPA maybe not the best party to handle the strategic oversight for Megaprojects in the UK. Instead, some authors have suggested that the PMO is the best party for defining, articulating, aligning, communicating and cascading the high-level strategic objectives to the lowest level in order to meet the high-level organisational goals [211, 243, 503]. This is supported by Braun [504], who argued that the PMO is increasingly viewed as a dynamic facilitator rather than a stable bureaucratic entity and a major part of their role is to manage relationships with all kinds of project stakeholders.

The integration of the PMO with the UK institutions – The above argument underlines that overlaps could occur between the functions of the proposed PMO and the IPA, which necessitates considerable attention to manage any confusion and ambiguity. Although the PMO will not deliver Megaprojects, it will support their successful delivery by integrating with different parties and bodies, including but not limited to UK government departments, sponsoring organisations and industry [378, 505]. For example, coordination and integration with existing bodies such as the NIC and IPA can help the PMO as a central authority to collect and share knowledge management, which can enable a better understanding of MRs. Thus, the current study suggests that the proposed PMO could be integrated with the IPA as a pool of skilled and experienced Megaproject delivery leaders [499].

According to the World Economic Forum [506], a strong national PMO could also help the government to choose the right projects to deliver. Hence, the PMO can help the UK government departments to identify interdependencies between projects and how to prioritise them, since this issue has been highlighted by a recent NAO report [19]. However, in the UK context, the NIC, which is an executive agency of the Treasury, is responsible for setting out what infrastructure Megaprojects are needed to secure sustainable economic growth across the UK [487]. The NIC is responsible for articulating a long-term vision for infrastructure, and the government will determine which projects are delivered [499]. Therefore, there is a need for an institutional framework for planning and delivering Megaprojects where the PMO can work with different bodies like the National Infrastructure Commission (NIC) to make informed decisions and to co-operate in the interests of the UK government. Therefore, the proposed PMO could not only help deliver Megaprojects correctly on time and budget but also bring the right benefits to society and the economy [506].

Practical challenges associated with the integration of the PMO with existing UK institutions – Although the PMO can bring advantages to the delivery of Megaprojects, this proposed national governance system is not free of challenges and barriers when it comes to the practical reality in the UK context. The current research identifies a number of challenges that need to be considered during the authorising process of the national PMO. The first challenge is the resistance to change [507]. Authors have argued that the implementation of the PMO structure in an organisation might potentially require a cultural change as a result of the new approach to managing projects, which in turn may take substantial time and effort for the new structure to be properly embedded in the organisation [380]. Therefore, owing to the cultural diversity among sponsoring organisations of Megaprojects (Public, Private, and PPPs) [478], the performance of the PMO could be obstructed for a significantly longer period of time.

The other practical challenge that could face the implementation of the PMO in the UK context is the difficulty in measuring the performance of Megaprojects [508]. The diversity of Megaproject types, scale and complexity, and the number of organisations involved make it difficult to measure the delivery performance and analyse a project's value [81]. In the UK, the IPA is responsible for measuring the delivery performance of public infrastructure Megaprojects to assess what is needed to improve the performance of the system and adjust the system accordingly [499]. Therefore, the PMO could utilise the IPA services to develop a comprehensive performance measurement framework specifically designed for the Megaprojects context. This suggestion is supported by some authors who have acknowledged that comprehensive performance measurement can play a decisive role in the success of Megaprojects under PPPs [509].

8.2.3 Critical Appraisal of COP

What is a COP, and why is it important? – A code of practice (COP) is defined as a set of written rules which explains how people working in a particular profession should behave [297]. It typically gives authoritative and practical directions about how professionals in a particular profession should behave or undertake tasks in order to comply with legal or professional obligations [510]. For example, the UK government uses the term Technology Code of Practice to define a set of criteria to help the government in designing, building and buying technology, which also is used as a cross-government agreed standard in the spend controls process [283]. The above definitions underline that the COP is a document that is expected to be used by practitioners to direct them on how to plan, manage and deliver things in a particular area such as Megaprojects. By benchmarking best practice, people and organisations can understand their obligations and uphold bespoke and high-quality standards. Therefore, a well-written COP could help organisations to clarify their visions, missions, values and principles in a particular occupational environment through linking them with a standard and agreed set of common rules [511, 512].

There are two terms in the literature for professional codes. First, the COPs or standards, such as the BS 31100:2008 Risk management – Code of practice [172]. Second, the guidance or guidelines, such as the guide of Risk Analysis and Management for Projects (RAMP) [170], which is considered to be an authoritative guide for risk management in project environments. Therefore, the differences between these terms, which tend to be used interchangeably, must be recognised. A guideline is defined in English dictionaries as something that can be used to help you plan your actions or to form an opinion about something [297]. This definition underlines that the key difference between COPs and guidelines is the former are mandatory documents while the latter are advisory documents. However, some COPs may not be mandatory, while others could involve legal or professional consequences if transgressed [510]. Hence the compliance with these COPs could unevenly adhere among organisations, especially in a complex multi-organisational environment like Megaprojects [47]. Evidence from the NAO reported that the compliance of the UK government departments with the guidelines of Major Projects Authority (now called IPA) work was too variable [513]. This report showed that only 62% of public Megaprojects had an Integrated Assurance and Approvals Plan (IAAP) in place [513]. This underlines that there is poor compliance with IPA guidelines, which means practices for best project delivery will be missed. This, in turn, could create confusion and vagueness among individuals when using such documents, which could mislead the decision-making process and eventually affect the performance.

How has the COP evolved over time in the UK? – In order to develop an effective COP, best practices need to be carefully considered by the developer organisation. The COP development process involves benchmarking comparison to best practices and testing them. For example, selecting a procurement route for a particular Megaproject by reviewing existing policies and incorporating recommendations from practitioners may be considered good practice [480]. A

COP may be developed by one organisation or more than one in order to have input from numerous sources [105]. In the UK, professional organisations are typically responsible for developing COPs and standards [514], such as the Institution of Civil Engineers (ICE), Association for Project Management (APM) and British Standards Institution (BSI). The early attempts to develop a code of practice can be traced back in the first half of the 19th century when the Royal Institute of British Architects (RIBA) was established, in 1834 [515]. The RIBA was a self-regulating body, which developed a Code of Professional Conduct to be adhered to by its members [516]. After a period of self-regulation, the UK government introduced a regulatory body called the Architects' Registration Council of the United Kingdom (ARCUK) in 1931, which was replaced by the Architects' Registration Board (ARB) in 1997 [516]. By following the same self-regulation processes and concepts, many professional organisations have developed their own versions of COPs, which have influenced the standards of public sectors. The APM is a typical example of these professional organisations, which has its own Code of Professional Conduct [395]. The Infrastructure and Projects Authority (IPA) is another example that has its own code of conduct for project assurance reviews [396].

What are the types of COPs? – COPs could be broadly classified into two groups: specific COPs or generic COPs. By definition, specific COPs are confined specifically to particular aspects and/or for particular circumstances. In contrast, generic COPs are designed as a comprehensive best practices framework that can be applied in different circumstances and scenarios. In the UK context, organisations may have their own specific COPs such as High Speed Two (HS2) or Crossrail, which are both designed to guide their practitioners and individuals to ensure consistency. For example, HS2 Ltd has developed a specific code of construction practice for phase 1 (London – West Midlands) of High Speed Two (HS2) [404]. This code sets out a series of proposed measures and standards of work, which shall be applied by the nominated undertaker and its contractors throughout the construction period [404]. In contrast, some organisations may have a generic COP that can be applied across many projects. For example, the asset management module, which is provided by the IPA provides advice on how to structure and manage the interaction between the project team and the corporate asset management function to deliver project outcomes [257]. The application of this module helps to ensure that the project not only delivers working assets at handover into operations but sustainable, longer-term benefits and managed asset risks through the life of those assets [257]. Given the fact that there are common elements across all Megaprojects, developing a special COP for delivering Megaprojects is necessary and has become imperative to manage them differently from conventional construction projects.

What is wrong with the systems that currently exist in the UK? – The various code of practices and guidelines for project management have been significantly influenced by developments in UK professional institutions. However, as far as can be ascertained, there is no specific COP for managing and delivering all Megaprojects in the UK; instead, the majority of Megaprojects are using the existing codes of practice and guidelines that can be applied for conventional projects. Using these conventional COPs or guidelines has two key limitations when it is applied to Megaprojects. The first issue is that Megaprojects are not a scaled-up version of a conventional project; instead, they are principally different and have a unique set of risks that not exist in conventional projects [62]. This means using conventional best practices could only be suitable for a certain period of time, which is normally shorter than the complex and turbulent life cycle in which most Megaprojects operate [6, 89].

The second issue is that most of the existing benchmarking tools for Megaprojects are guidelines rather than COPs. The Project Initiation Routemap is a typical example of these tools that are provided by the IPA [222]. This routemap helps both public and private sector infrastructure providers to improve the delivery of their projects and programmes [283]. However, although this routemap provides a good link between the project and the organisation's strategic priorities, it is associated with a number of limitations and weaknesses. The first issue is that this routemap is not a live document but a static one, i.e. there is no frequent update to it, which is not suitable to cope with the dynamic and changeable nature of Megaprojects [67]. Hence, Megaprojects require a live document to be updated frequently and periodically as new practices emerge by a relevant authority or body to accommodate fresh practices and procedures [480]. The second issue is that the routemap is an advisory document since it provides advice on how to structure and manage stakeholders in Megaprojects [257]. Although providing advice rather than imposing it is more useful to give more freedom to the project team to cope with the evolving nature of Megaprojects, many of these guidelines and advice are not followed by the project team. This demonstrates that developing a specific COP for Megaprojects to be influenced and commissioned by a high governing authority such as a PMO at the national level has the potential to increase the level of compliance with best practices.

The implications of the COP for the existing standards and guidelines – Despite the weaknesses of existing codes of practice in the UK, the proposed COP in this study needs to be developed in conjunction with existing current guidelines, codes of practice, standards and other frameworks to ensure consistency and avoid contradiction. The current research study suggests a need to move towards standardising best practices periodically by a central authority at the national level alongside the guidelines to keep the delivery more resilience. The rationale behind this claim seems to be that guidelines are recommendations which can easily be overlooked, compared with standards, which are mandatory actions or rules that give formal policies support and direction [517]. Therefore, the current study suggests that the proposed COP system for Megaprojects be developed, mandated and updated by the proposed PMO. Thus, the PMO needs to design, develop and maintain a standard reporting framework based on the collaboration with different sponsoring organisations to ensure that all performance reports are produced to the same set of standards [518]. Similarly, there is a need for a robust, efficient process to consolidate the data so as to produce an accurate databases. This, in turn, will help to ensure a clear, consistent and coordinated common COP to plan, review and deliver Megaprojects [392].

8.2.4 Critical Appraisal of NCF

What is a contract and why is it important? – A contract is defined by the PMI as a legal document between a buyer and a seller that represents a mutually binding agreement that obligates the seller to provide the specified products, services, or results, and obligates the buyer to provide monetary or other valuable consideration [78]. In contrast, the APM defines a contract as an agreement made between two or more parties that creates legally binding obligations between them and sets out those obligations and the actions that can be taken if they are not met [371]. Bing *et al.* [519] defined an engineering contract as the legal linkage between the client and contractor, who are bound together through the allocation of risk and profit in the contract. The above definitions underline that contracts can outline expectations for the contracting parties by translating, converting and incorporating these expectations into contractual clauses and provisions. Therefore, the contractual arrangements can be simple or complex, based on the simplicity or complexity of the expectations of contracting parties.

In the Megaprojects context, contracts can be used to decompose large complex systems like Megaprojects, which are difficult to comprehend as a whole, into smaller and more manageable packages [197]. For example, a high-speed railway Megaproject can be divided into a number of packages including railway roadbed construction, track-laying, station building construction, storehouse construction, electric work, railroad signal work, and communication facility construction [65]. Therefore, contracts can be used as tools to transfer and allocate risks among the contracting parties of a project, where each risk needs to be assigned by the appropriate contracting party most efficient and capable to handle that risk [195]. Contracts can also be used to manage stakeholder complexity at an early stage in a project by embedding greater flexibility regarding the roles and responsibilities of stakeholders [520]. Therefore, it can be argued that contracts could shape the behaviour of the contracting parties involved and thus have a major impact on project success [255]. The above argument underlines that the role of the contract in Megaprojects is thus critical in ensuring effective delivery performance in this sort of project.

What is the existing contract system in the UK? – Since 1931, The Joint Contracts Tribunal (JCT) has produced standard forms of the construction contract, guidance notes and other standard forms of documentation for use by the construction industry [521]. The JCT may be described as a 'traditional' contract and has, for many years, been seen as the standard building contract for use in the UK, not internationally [521]. However, in 1993, the New Engineering Contract (NEC) was introduced by the Institution of Civil Engineers (ICE), which has played a major part in helping the engineering and construction industry do things differently and better [522]. The NEC is the most popular family of contracts across the UK construction sector and especially among infrastructure Megaprojects in the public sector [188]. The NEC contracts, in fact, clearly require that all parties act collaboratively in a spirit of mutual trust. For example, the 2012 London Olympics programme and Crossrail are typical examples of Megaprojects using the NEC suite of contracts, with emphasis on the target cost option, a trend started by the Channel Tunnel Rail Link (High Speed 1) [6]. The NEC4 is the latest version of the NEC contracts family, which was launched in 2017 to enhance the previous version, NEC3, by providing new features and new forms of contract [522].

What is wrong with the current contracts system? – Despite the contributions of NEC3 and NEC4 to the construction industry and Megaprojects in the UK, they have a number of limitations and pitfalls that have been well diagnosed in the literature. The key issue can be seen with the dynamic nature of Megaprojects that limits the ability of these contemporary contract approaches to manage and mitigate gaps in the contract [6]. Owing to their long life cycle, scale, scope uncertainties and stakeholders uncertainties, Megaprojects are associated with high and frequent changes in many project aspects including planning, design, implantation and operation [31, 65]. For instance, what was originally thought of as a transportation project may become an urban-development or a landscape-preservation project, too, as was the case with the HSL South [498]. This underlines that what is perceived as best practice to manage and handle different project aspects may be only applicable in certain circumstances [6]. Therefore, current practices are no longer appropriate in a changing environment, and there is a perceived need to adjust, update, or replace them over time. The problem lies with the fact that it is hard for the contracting parties to anticipate any changes to the best practice that reflected their requirements at the contract signing date [480]. Therefore, it can be argued that the existing NEC3 and NEC4 are not flexible enough to cope with the scale and complexity of Megaprojects [6]. These weaknesses have been recognised by the NAO by identifying some issues from which the existing contractual arrangements of Megaprojects suffer [523]. A recent NAO report showed that not recognising the technical challenges is one of the common causes of project failure and cost overruns in Megaprojects [523].

Accordingly, a contract strategy must not only provide incentives to deal with risks but also must be flexible enough to accommodate unforeseen circumstances as they arise [524].

8.3 Managing and Mitigating Megaproject Common Risks using the Proposed Approach

8.3.1 Adaptability to Legislative and Political Changes (MCR1)

The Delphi validation sessions confirm the viability of legislating and enabling a specific ACT for Megaprojects (ACT) similar to the concept of PPP laws and acts in different countries such as the UAE, France, Poland and Mexico [525]. It also confirms the viability of the conceptual and practical implications of developing a legislation exemption mechanism under this ACT. To manage and mitigate legislation changes, the literature revealed that statutory instruments such as the Act of Parliament if enacted and enforced could increase the stability of the delivery environment in which Megaprojects are operated [223]. Evidence showed that enacting and enforcing appropriate laws and regulation can enhance the stability of the regulatory and political environment to develop Megaprojects [223]. The rationale behind this argument is the Acts of Parliament can demonstrate legal/political commitments towards the promotion of a stable delivery environment for Megaprojects. Thus, having statutory instruments would probably have implications on the government and legislators (lawmakers) to decrease frequent changes to legislation that could severely impact the delivery of Megaprojects. A recent paper also showed that having a well-defined legal system and powerful judiciary may lend credibility, thus facilitating long-term commitments by contracting parties [525].

Statutory instruments such as Acts of Parliament can also expressly establish the right to compensation for changes in legislation and policies which arise during the implementation and/or operation phases. This is supported by the United Nations, which recommend that an Act should allow for extending the concession period for circumstances like project suspension brought about by Acts of the contracting authority or other public authorities [496]. For example, the Major Transport Projects Facilitation Act No. 56 of 2009 can provide compensation for major transport projects in Victoria for some extreme events [493]. Although the compensation for legislation changes is not a new thing, it is very often not adequate to satisfy the expectations of those impacted by a Megaproject. Therefore, Acts of Parliament can provide clear clauses to obtain government guarantees for extending the concession period and milestone dates of the project as a compensation measure to cover any additional costs arising from external risks such as changes in laws [526]. Extending the concession period is probably a more suitable measure to compensate Megaprojects for the likely delay and cost overrun resulting from complying with legislation changes in sensitive areas such as health and safety, climate changes, CO2 emissions, etc. Therefore, it can be argued that Acts of Parliament in such circumstances can reduce the impact of some elements of legislative risks; hence enable Megaproject owners, operators and practitioners to manage them effectively.

The other measure that could increase the adaptability of Megaprojects to the risk of unexpected changes in legislation and policies is the deliverables of the legislative exemption mechanism under the new ACT. This mechanism can provide Megaproject practitioners with a systematic process that enables them to be exempted from the impact of possible legislative change after rationalising and assessing it. It also can encourage the Megaproject delivery team to liaise with relevant authorities and external stakeholders like the public in very early consultation sessions to identify and resolve issues associated with legalisation. Therefore, if an exemption proposal from a particular piece of legislation is secured and approved by parliament, it can help reduce both the probability and impact of that legalisation risk. For example, under the German Law, the Private Partner will be secured by virtue of law against expropriation and discriminating legislation [216]. Therefore, countries with clear and robust laws and policies often have more stable and predictable legal frameworks than those that leave more aspects open for negotiation in individual contracts. This is because, when a Megaproject has some elements of private finance, the commitments of the host government are often accommodated into national laws by enabling legislation, which allows greater certainty that the relevant undertakings will take precedence over competing, and often inconsistent, laws and regulations [242].

The mechanism can also allow for the suspension of compliance with laws, policies and regulations for a defined period to reduce the turbulence that could result from instant compliance. For example, according to the IPA and as reported by the NAO, 10 existing Megaprojects in the UK, such as the Department for Transport's M20 Lorry Park, may face additional demands as a result of Brexit, requiring system changes leading to increased costs and time pressures [284]. This is probably due to the fact that projects located in the UK will no longer be eligible for the European Investment Bank (EIB) financing. If the exemption mechanism had been in place before Brexit and applied, it could have alleviated the financial losses and reduced any turbulence. Therefore, it can be argued with high confidence that the exemption mechanism under the new ACT can increase the adaptability of Megaprojects to legal and political changes.

8.3.2 Aligning Stakeholders' Expectations (MCR2)

The Delphi validation results showed a good agreement among the experts on the development of a PMO at the national level to act as a central body providing expertise and resources for Megaprojects in the UK. The current research argues that the Project Management Office (PMO) can play a fundamental role to improve the stakeholders' alignment; hence improve the delivery of Megaprojects [78]. Further, the role of the PMO as the main facilitator and coordinator of Megaprojects can help both internal and external stakeholders to identify, articulate and communicate their strategic objectives clearly from very early stages [243]. The validation results show that the PMO needs to be authorised to communicate and liaise regularly with different bodies like NIC, HM Treasury, devolved authorities and local authorities to be supplied with high-quality data on Megaprojects [507]. This task can help the PMO to compare and match these data and solve any crossing points and potential interfaces at a very early stage [220].

Fundamentally, the tasks of PMO may be derived from these key stakeholders' requirements and their need to delegate management obligations [270]. The PMO helps to identify project stakeholders, understand where they come from, help them find solutions, and integrate them all to make better decision-making process [211]. For example, external stakeholders very often do not recognise and differentiate between what they "need" and what they "want" from the project at the early appraisal stages. In fact, external stakeholders tend to use these two terms (need/want) interchangeably, where the “need” is a non-negotiable request, and the “want” is a negotiable request. As a result, external stakeholders often discover their “needs” during the implementation and operational phases, which in turn could lead to excessive delays in a project. Therefore, with the availability of the right recourses and capabilities, the PMO can help external stakeholders discover what they “need” from the project and articulate it at very early stages and match it with the “needs” of internal stakeholders, i.e. project outputs and outcomes. Hence, the PMO can provide better directions towards stakeholders’ engagement from the outset, and this can reduce the probability and impact of conflicts, disputes and misalignment [244, 245].

The other significant value of the PMO is about bringing together all stakeholders, building a relationship, understanding people and facilitating proper conversation at the appropriate time. As a result, in carrying out all of these tasks, the PMO can create a “problem-solving environment” rather than a “finger-pointing environment” [527]. This argument was also supported by Unger *et al.* [270], who argued that the PMO might also adopt a cooperative stance and handle the information responsibly to establish trust among the stakeholders at large and facilitate information and knowledge sharing. This, in turn, can lead to higher learning gains and inspire all stakeholders to think collaboratively as one unit and integrate their disparate definitions of a problem [527]. Having all the stakeholders agreed on what the problem is and how to solve it, the degree of alignment among them can be increased, which ultimately contributes to the project success. Therefore, the role of the PMO can dramatically improve the alignment of stakeholders’ expectations in Megaprojects, hence their controllability and manageability.

8.3.3 Scaling-Up (MCR3)

The Delphi validation sessions showed a good degree of agreement among the experts about the viability and practicality of developing and mandating a dynamic COP for Megaprojects in the UK. This is supported by Smith and Jobling [6] who argued best practices are applicable to Megaprojects due to emerging complexity. Therefore, other authors argued that that developing comprehensive codes of practice specifically to Megaprojects has the potential to manage scaling-up risks; hence improve the delivery of Megaprojects [129]. For example, Qazi *et al.* [108] called for further empirical research to investigate the best practices in managing complex interdependencies between project complexity and resulting risks. Accordingly, this study argues that, because the development of this COP is an iterative process, where different bodies/parties can input their own standard requirements, it has the potential to improve the delivery of Megaprojects. The rationale behind this argument is that specific codes of practice can provide sets of best practices, procedures and methods that are specifically designed for all Megaprojects and only Megaprojects. For example, the COP can help a Megaproject to obtain benefits from best practices and lessons shared by Megaprojects sponsored by different UK Government Departments as quickly as possible. Further, the dynamic nature of this COP makes it more suitable to reactively address scaling-up issues in Megaprojects simply because best practices may be applicable only in certain circumstances, which can change dramatically and rapidly in the Megaprojects environment [6]. Hence it can be argued that mandating this COP can help practitioners to manage and reduce the probability of scaling-up risks inherent in Megaprojects.

Compliance with codes of practices can ensure that Megaproject practitioners are staffed and equipped with more focused tools to properly manage and mitigate scaling-up-related risks in Megaprojects instead of using conventional tools. Accordingly, this can educate Megaproject practitioners about best practices for Megaprojects; hence, it can raise the delivery team’s awareness of the scale of these practices. For example, engineers carrying out the design or visibility studies in Megaprojects can make huge mistakes in not recognising or addressing scaling-up issues because many of them are experiencing projects on such a scale for the first time [528]. In fact, only a few sponsors are well informed in the sense of having relevant in-house experience or the capability to deal with projects on such a scale. In this regard, assessing the in-house capabilities at very early stages is significant to control the scaling-up issues inherent in Megaprojects and search for alternative resources and capabilities. Thus, the COP could probably help improve the experience of many new people who have joined the delivery team involved in Megaprojects.

The compliance with this COP can create a line of consistency and recognition of best practices to be accommodated into the contractual arrangements of Megaprojects at different organisational levels. Therefore, the rationale for having the COP is to enable the delivery team, owner and operator of Megaprojects to demonstrate their commitment to compliance with the recommended best practices. Accordingly, this can help Megaprojects to avoid and reduce the errors, rework, delays, difficulties and costs associated with scaling existing practices up to Megaproject scale [6]. Thus, the COP can help to measure whether Megaprojects are formally compliant with the procedures and requirements best suited to them, and hence increase the accountability and authority to manage the scaling-up risk.

8.3.4 Operability (MCR4)

Authors argue that having a central PMO can help can influence operation project operation; hence manage and mitigate the risk of lack of operability of Megaprojects [246]. The rationale behind this argument is that the PMO, as the main facilitator and coordinator, can help to ensure and codify the engagement of expertise in Megaproject operation at very early appraisal phases [247]. This early involvement can create a good line of coordination between the implementation team (design and construction) and the operation team to identify unforeseen operational interfaces such as network management and train operations in the case of transportation Megaprojects. For example, in the UK, Crossrail has had operator involvement from the outset, which helps to support the engineering design of the project and avoid rework which could result from unforeseen operational consequences [529]. Lessons from infrastructure projects in Australia showed that the involvement of the key operation team in the design phase could result in better functionality and long-term viability of a project's facilities [480]. This is in line with the lessons provided by the DfT and IPA that recommended careful planning to be undertaken by the accountable organisation to identify and communicate widely the point of no return after which there will be operational impacts to the wider system even if a no-go decision is taken [530].

When the PMO codifies the requirements of early engagement for operation expertise and measures the compliance with them, it can ensure clear accountability for the decision on whether to operate the project or not [391]. The rationale behind this argument is probably because the operator is ultimately accountable for the operational activities, so it can recommend changes to be made in project design to be smoothly operable from the outset (i.e. during the appraisal phase). Senior operator experts can trigger risks that could impact the performance of project operation due to their extensive and established experience and expertise [46]. They can also provide objective advice, and they can spot certain things much more easily than other project members due to their training and actual engagement. Furthermore, they can understand how the functions of complex systems work together like high-speed rail Megaprojects [188]. Therefore, it can be argued that the PMO and COP can both serve to reduce the possibility of technical surprises that could result during the operation phase.

Megaprojects that have progressed smoothly through the design and construction phases still have a chance of having unexpected operational problems. This can happen when the operation team who will ultimately operate and maintain the project is excluded from the decision-making process during the implementation phase [531]. For example, if a signalling software requirement fault is detected at the early appraising phase in a high-speed rail Megaproject, the consequences for the project’s outputs and outcomes will be relatively mild. However, if the same fault is not managed and mitigated until the operational phase, the consequences will be considerably higher and more adverse for the project’s outputs and outcomes alike, such as train accidents, rail shutdown or excessive delay. Inadequate feedback loops between the delivery team and operation team during the conceptual design have implications on understanding other issues beyond the architecture and expanding the design aspects. These include but are not limited to implications on the procedure for implementation, resource allocation for the operation, aligning stakeholders’ expectations, achieving commercial viability, and strategic planning. Therefore, it can be argued that codifying early involvement of operation experts could both reduce the probability and impact the risk of lack of operability, i.e. when it is not operable and/or maintainable.

8.3.5 Incomplete Contract (MCR5)

The Delphi validation sessions confirm the viability and the applicability of the NFC to Megaprojects to manage and mitigate incomplete contracts. The current study argues that having contractual arrangements can help to manage and mitigate such risks if applied correctly. Some authors argued that Megaprojects need to be broken down into a number of packages because large complex systems are difficult to comprehend as a whole [197]. Therefore, each package can be procured by the most suitable contractual arrangement option based on factors like level of uncertainty, the proportion of standard activities to unique activities involved for each package, etc. [186]. By doing this, incomplete contract risk can be reduced, especially in the case when there are unique elements in the project that cannot be compared with standardised projects. In the UK, the London 2012 Olympics used the same concept to great success by relying on fixed-price contracts to deal with known conditions and risk-sharing and target-cost contracts to deal with less predictable projects, such as the construction of London Stadium [186]. Based on the above argument, it can be argued that having an appropriate contract system can increase the level of flexibility needed to overcome the incomplete risks in Megaprojects.

The other possible mitigation measures are managing the interfaces by procuring different project packages in a concurrent way to reduce the risk of interfaces [67, 203]. This is supported by Ahmed [198], who argued that a good project manager should always have multiple concurrent options available at any point of reference. This means there is a need to select the most appropriate procurement strategy as a whole by asking questions on whether this package can be procured with one party or more, is it the right form of contract for this package, what is the whole picture/goal of the project, or what is the full scope of the project [137]. By doing this, the degree of coherency can be increased by making sure that all things fit together. This can help in managing interfaces, especially as Megaprojects, are often loosely coherent and framed as a single unitary package [498]. This also means more time, consideration and attention should be given to the procurement strategy. Therefore, it can be argued that procuring different project packages in a concurrent has the potential to reducing the risk of incomplete contracts to Megaprojects.

The other possible mitigation of incomplete contract is the incorporation of collaborative behaviours and incentivising shared outcomes schemes, which both can also contribute towards improving the contractual arrangements in Megaprojects [110, 134]. This requires another level of collaboration and alignment between the client and the supply chain on the complexities associated with the delivery of Megaprojects. This is in line with the HM Treasury statement that the ideal scenario for Megaprojects is to achieve alignment between the capability of the client and supply chain and the complexity of the challenge to deliver maximum value, supported by a sponsor who can provide appropriate strategic oversight [532]. A practical example of good collaborative behaviours can be found in the 2012 London Olympics, where the contractual arrangement used on this project was designed to support the collaborative relationships between the main contracting parties including the Olympic Delivery Authority, client and principal contractors [410]. Based on the above, it can be argued that incorporation of collaborative behaviours and incentivising shared outcomes schemes can partially mitigate and manage the incomplete contract in Megaprojects simply because no single contract system is going to be perfect to handle the evolving nature of Megaprojects.

8.4 Research Implications

8.4.1 Theoretical Implications

This section discusses the theoretical implications of the research findings to both the immediate body of knowledge and parent disciplines and fields of knowledge. The placement of the research findings within the context of theory and literature is important because it ensures that the contribution to the body of knowledge is clear and explicit. In this regard, the current research study is exploratory, and it is well-positioned within the theory of risk management.

The first theoretical implication is that this research study is the first study which has combined four MCR mitigation measures proposals (ACT, PMO, COP and NFC) to manage and mitigate MCRs collectively. Therefore, this research study represents a paradigm shift from conventional risk management towards an innovative risk management methodology by taking into account the scale and complexity of Megaprojects. While extensive research studies have been carried out on risk management in Megaprojects, most of them involve elements of classic risk management that have been critiqued by many authors in the context of Megaprojects [6, 39, 183, 187]. In fact, there is still very little scientific understanding of how to identify, manage and mitigate MCRs systematically. Therefore, it can be argued that the current study succeeds in filling the knowledge gap by introducing a change to the current risk management thinking in relation to Megaprojects. Therefore, this research responds to the findings of Irimia-Diéguez *et al.* [48], who suggested that more research is required to improve megaproject management and risk process management. This underlines that this research helps to expand the knowledge boundaries in the risk management of Megaprojects, which in turn opens the door for further theoretical and empirical research in this area [63].

The second theoretical implication is related to the four mitigation measures proposals (ACT, PMO, COP and NFC), which constitute the proposed approach to risk management for Megaprojects. The proposed approach was developed and grounded based on a rigorous literature review with empirical findings from AGT interviews with Megaproject experts. This is in line with the recommendation made by Guo *et al.* [81], who advocate for further empirical studies of management systems in Megaprojects to improve managing risks in this sort of project. The proposals relating to MCR mitigation measures were empirically validated by another set of Megaproject experts using the Delphi technique. The combination of these measures is a unique package of its own, especially when they were validated to reflect the uniqueness of the UK context. No previous study has investigated this combination in a Megaprojects context. Although these mitigation measures are yet to be fully developed, this research study highlights the role of these proposals in Megaprojects, and this prepares the ground for scholars to conduct further theoretical and empirical studies in risk management and Megaprojects.

Traditional Megaprojects literature tends to identify risks from a general perspective without considering how these risks are common to all Megaprojects [23, 46, 47]. For example, Patanakul [47] identified common problems in managing IS/IT Megaprojects in the public sector only, whereas Lam [23] provided a sectoral review of risks associated with infrastructure Megaprojects without indicating to what extent they are common to all Megaprojects. The current research study fills this gap by providing a systematic process to identify MCRs from the literature that can be applied by other scholars to produce similar outcomes. Therefore, a unique list of MCRs specific to Megaprojects and only Megaprojects were explored by this research. Accordingly, it can be argued that the current research provides expanded discussions on the process of risk identification in Megaprojects.

8.4.2 Practical Implications

This section discusses the implications of the research findings in a practical context by placing these findings within the body of knowledge published by industrial organisations, professional bodies and governmental institutions. The placement of the research findings within the practical context is important to ensure that the contribution to practice is clearly and explicitly made.

The Delphi results confirm the viability of legislating and enabling a specific ACT for Megaprojects similar to the concept of PPP laws and acts in different countries such as the UAE, France, Poland and Mexico [525]. It also confirms the viability of developing a legislation exemption mechanism under this ACT. Although the UK has different methods and processes to secure planning permission for Megaprojects like the Hybrid Bill, Development Consent Order (DCO) under the Planning Act 2008, etc. [338], the main purpose of these statutory instruments is to obtain the permission to develop Megaprojects rather than protect them from the implications of changes in policies and legislation such as the implications of Brexit. For example, according to the NAO, the scale of regulatory change is likely to increase as the UK exits the European Union (EU), requiring changes to regulatory models [533]. This is a very high risk of Megaprojects. Therefore, the exemption mechanism, if in place, could reduce and mitigate such risks significantly.

The Delphi results also confirm the necessity of establishing a PMO at the national level to provide resources, best practices and strategic oversight mechanisms to the delivery of Megaprojects across the UK supported by a bottom-up progress-reporting mechanism. This idea corroborates the findings of

NAO, which claimed that, although several different central bodies in the UK are involved in improving the performance of Megaprojects, none has a central overview [19]. The NAO recognised that people with the experience and skills to deliver complex projects, particularly within a government context, are in short supply [478]. Therefore, the PMO can address the weaknesses in capability that undermine the UK government's ability to achieve its objectives, as reported by the NAO [478]. The idea of the PMO is also in line with the lessons shared by the IPA and DfT that call for ensuring governance and reporting structures, oversight and the capabilities of the delivery organisation to adapt ahead of the next stage to ensure the required capability and capacity are in place [530].

The Delphi findings also confirm the role of the PMO in reflecting the requirements of different relevant authorities and UK Departments in a comprehensive COP that needs to be mandated by Megaprojects and reflected in their contractual arrangements. Again, this idea is in line with the recommendations of the IPA, which recommended that UK Departments cooperate closely and undertake integrated policy and planning to realise these benefits and manage the divided accountabilities carefully, as interdepartmental structures are rarely established to align with the major project [530].

The Delphi results also confirm the need for the NFC to improve the delivery of Megaprojects. The NFC calls for the use of a selectively flexible contract for different project packages by considering the level of complexity and uncertainty in order to increase flexibility. It also calls for encouraging and maintaining good collaborative behaviours among the contracting parties. This should be supported by the need to accommodate within the NFC shared-outcome mechanisms where various contracting parties are jointly incentivised to the success of the overall project. All of these NFC features are in line with the recent IPA lessons provided for all Megaprojects which suggested that, in order to reduce the system integration risk, the delivery organisation needs to let contracts in a way that will increase flexibilities, limit the complexities, and incentivise suppliers to work collaboratively across contract boundaries [530].

Based on the above argument with reference to the Delphi validation results, it can be argued that all the MCR mitigation measures proposals (ACT, PMO, COP and NFC) have great potential to improve the delivery of Megaprojects in the UK context and in countries with similar systems and circumstances. The combination of these proposals serves as a novel approach to risk management that provides a structured methodology to identify, manage and mitigate MCRs for Megaprojects and only Megaprojects. Therefore, the proposed approach should be viewed as an important component of holistic and proactive project management. By no means is this the definitive approach for managing and mitigating all risk associated with Megaproject delivery. It does, however, specifically aim to equip sponsors, clients, operators and practitioners with concrete mitigation measures to manage and mitigate elements of most MCRs deemed crucial for Megaproject success.

If the proposed approach is properly performed, it could increase the ability of Megaproject practitioners to plan, identify, analyse, manage, communicate and mitigate MCRs, and thus enhance the delivery performance. Therefore, it is expected that the proposed approach will increase the awareness and capability of Megaproject practitioners in understanding and managing MCRs. By doing so, practitioners will be able to understand some elements of uncertainty permeating through Megaprojects and thus make improved and informed decisions.

It can be argued that the combination of the MCR mitigation proposals can provide a strategic framework for UK Government Departments to improve the delivery performance of Megaprojects. Such a framework can serve as a blueprint for developing a Comprehensive National Strategy (CNS) to improve the delivery performance of Megaprojects in the UK. Therefore, the proposed approach is not a replacement for existing risk management approaches and procedures such as the HM Treasury guidance on the optimism bias (Green Book). Though the proposed approach can contribute to minimising the cost and time overrun in Megaprojects; hence, it provides a better chance to deliver Megaprojects with the desired benefits.

8.5 Summary

This chapter has briefly summarised the content of the previous chapters and outlined the most important results and findings of the research. The chapter has critically reviewed the elements of the proposed approach (ACT, PMO, COP, and NFC) in the current UK practice. It also has discussed the implementation of the proposed approach in managing and mitigating MCRs. The chapter finally discussed the results of the research within the theoretical context and practical context.

Chapter 9 Conclusions, Recommendations and Implications

9.1 Introduction

This chapter addresses the research findings to conclude the thesis. Section 9.2 addresses how the aim and objectives set out in Chapter 1 were achieved. Section 9.3 emphasises the original contribution made by this research study from both theoretical and practical perspectives. Section 9.4 discusses the limitations of the research study. Lastly, Section 9.5 provides recommendations for future research and areas which need more investigation.

9.2 Achieving the Research Aim and Objectives

The aim of the current research study, as stated in Chapter 1, is to improve risk management of Megaprojects, hence improve their delivery performance. To fulfil this aim, four objectives were set, which are discussed in the following sections.

9.2.1 Objective 1: Understand the Nature of Megaproject Risks

This objective sought to gain a better understanding of Megaproject Risks (MRs) and differentiate these MRs from risks in conventional construction projects. This objective also sought to identify a comprehensive list of MRs.

This objective was addressed in Chapter 2 and achieved by synthesising the existing body of knowledge of MRs through a systematic literature review supported with content analysis method. This process resulted in identifying a comprehensive list of 38 possible MRs, as listed in Appendix B.

The literature review revealed that few studies had been carried out to distinguish MRs from conventional risks. The literature also showed that most of the existing studies tend to use generic lists of risks, which are not suitable for Megaprojects, which inherently involve risks that occur outside the scope of conventional projects.

This research study found that the impact of MRs on project delivery tends to significantly and rapidly increase as project scale increases, like a snowball. Further, MRs can cause the conversion of a non-critical path to a critical path; thus, it can escalate to affect the whole project and sometimes create strategic risks to project sponsor and project delivery organisation. Therefore, Megaprojects face a unique list of MRs that do not exist in conventional projects.

MRs can be grouped into three main categories. Firstly, MRs occur in all Megaprojects and only in Megaprojects (MCRs). Secondly, MRs are partially common to some Megaprojects but has also have some elements that are common to all Megaprojects (Partially Common MRs). Thirdly, MRs arise from the way a project is managed or from events in its immediate internal environment (Specific MRs).

The research study contributes to the knowledge by providing for the first time a comprehensive list of 38 MRs. Thus, the research improves the understanding of MRs by differentiating them from conventional risks; hence supporting practitioners with their decisions. This comprehensive list of MRs can help practitioners to rank and prioritise MRs on different bases and exclude MRs deemed irrelevant to Megaprojects. Accordingly, the new list of MRs can help practitioners to assign appropriate mitigation measures to MRs deemed critical to all Megaprojects.

9.2.2 Objective 2: Critical Appraisal of Risk Management Weaknesses in Megaprojects

This objective sought to investigate the current risk management practices in Megaprojects. The objective also sought to identify the limitations and weaknesses of the contemporary risk management approaches in the Megaprojects context.

This objective was addressed in Chapter 3 and achieved through conducting a critical appraisal procedure in three steps. Step 1 involved a detailed review of Megaprojects literature to identify factors found to challenge the success of project management in such projects. Step 2 involved a detailed review of risk management literature to identify the limitations and weaknesses of the existing risk management approaches. Step 3 involved mapping the risk management limitations and weaknesses against the project management challenges of Megaprojects.

The critical appraisal revealed that many of the conditions for the successful application of conventional risk management approaches were not satisfied in

Megaprojects; in particular, problems arose from incomplete, insufficient and inaccurate data. These constraints severely limit the capability of conventional methods to manage risks in Megaprojects to the extent that these methods could not produce meaningful and realistic results. Further, conventional approaches tend to rely on best practices, which may be applicable only in certain circumstances. However, the environment in which Megaprojects operate is evolutional, complex and turbulent; hence, conventional approaches are not well suited to such conditions. Thus, to manage MRs in a similar way to conventional risks is a misleading oversimplification. Hence, Megaprojects require a different approach to risk management.

Based on the critical appraisal analysis, the current research study found that continuing to use conventional risk management in Megaprojects may not be well suited for handling MRs for three reasons. First, conventional approaches do not differentiate between Megaprojects and conventional projects, yet the former are significantly different from the latter. Second, conventional approaches tend to mitigate the symptoms rather than the causes behind the poor delivery performance of Megaprojects. Third, conventional approaches are costly as they do not take into consideration that around one-third of Megaprojects have a satisfactory delivery performance.

This research study contributes to the existing risk management body of knowledge by highlighting the limitations and weaknesses related to applying conventional risk management approaches in a Megaprojects context. Therefore, this research enriches the understanding of those limitations and weaknesses, which can stimulate practitioners to advance risk management practices, as well as encouraging academics to raise research propositions. As a result, the implications of critical appraisal emphasise and demonstrate the need for a new approach to managing and mitigating risks in Megaprojects beyond the conventional approach.

9.2.3 Objective 3: Identify Megaproject Common Risks

The purpose of this objective was to gain a better understanding of Megaproject Common Risks (MCRs). The objective also sought to confirm the identity of

MCRs deemed crucial for the delivery success of all Megaprojects and only Megaprojects.

This objective was addressed in Chapter 4, and it was achieved through a new approach, as justified and explained in Chapter 5 (Section 5.5). This approach involves selecting a shortlist of MCRs from the comprehensive list of MRs by proposing a systemic risk identification process. The identification process led to the identification of five MCRs, as defined in Chapter 4 (Section 4.3).

The MCRs are Adaptability to Legislative and Political Changes (MCR1), which is the Megaprojects' inability to adapt to unexpected changes in legislation, policies and regulations by the local or national government during the development process that could affect the project outputs; hence the commercial viability. Aligning Stakeholders' Expectations (MCR2), which represents aligning the views, needs and expectations of the key project stakeholders (both internal and external) at different organisational levels (corporate, strategic business unit and operational) to deliver the project within the anticipated outputs and to achieve long-term commercial viability.

Scaling-up (MCR3), which is the Megaprojects' inability to adapt to the transition of resources, practices, processes, procedures, means and methods, and systems from the conventional scale (small or large) to Megaproject scale due to three key dimensions: project scale by any metric, project duration and project complexity. Operability (MCR4), which is the lack of effectiveness of project facilities in performing in line with the necessary functionalities as designed upon commissioning. Incomplete Contracts (MCR5), which are the deficiencies in recognising Megaprojects' boundaries due to their massive scale, turbulent life cycle and inherent complexity; hence, they do not accommodate the necessary provisions, actions and mechanisms to effectivity manage risks in Megaprojects.

It was evident from the literature review that little academic research has been carried out to investigate and identify MCRs. It was found that the identification of MCRs is a challenging and subjective task, which can be interpreted differently by academics and practitioners. It was also found that there is no common risk terminology across Megaproject disciplines and departments.

The research study has produced for the first time a unique and repeatable process for identifying MCRs, which practitioners and academics can use and repeat the procedure and potentially apply it to their own study/research/project. Thus, this research contributes primarily to a new risk identification method that is capable of identifying and prioritising MCRs deemed critical for the success of all Megaprojects and only Megaprojects.

The research study also identified for the first time an original list of MCRs, with a clear and precise definition of each MCR. By identifying MCRs, practitioners will gain a better understanding of how to assess and evaluate these risks, which will, eventually, help them to work out the proportional impact of MCRs on Megaproject delivery in terms of cost and time. The identification of MCRs provides the basis to conceptualise and develop an approach to investigate what can be done to advance risk management practices in Megaprojects.

9.2.4 Objective 4: Develop a New Approach to Manage and/or Mitigate Megaproject Common Risks (MCRs) Collectively to Suit the UK Context

This objective sought to develop a new approach to manage and mitigate MCRs systematically and in a better way, hence to improve risk management in Megaprojects. This objective was addressed in Chapters 4, 5, 6 and 7.

Chapter 4 presented, justified and synthesised the theoretical concepts/constructs and fundamental principles that underpin the development of the proposed approach to risk management for Megaprojects. Chapter 5 presented and justified the research method adopted to collect and analyse the required data to develop the proposed approach. Chapter 6 presented the empirical research findings from the fieldwork study. Chapter 7 discussed the development process of the proposed approach to risk management in Megaprojects, which involved three phases: pre-fieldwork study, fieldwork study and post-fieldwork study.

The pre-fieldwork phase consisted primarily of the creation of the research background and involved a rigorous literature review on both Megaprojects and Risk Management. This phase provided the basis to present and justify the synthesis of theoretical concepts and fundamental principles that underpin the development of the proposed approach to risk management for Megaprojects. Conceptualising the research foundation started with identifying a comprehensive list of recommended mitigation measures for Megaprojects from the literature and screening them through a systematic process into a shortlist of Critical Mitigation Measures (CMMs). The theoretical concepts that underpin both MCRs and CMMs were then synthesised to conceptualise a new approach to risk management in Megaprojects. To the author's best knowledge, no other research in the area of risk management and Megaprojects has followed a similar systematic procedure to developing similar approach, and this is the first attempt to do that.

The development of the proposed approach served as a theoretical lens for the empirical analysis for the current research study. It also provided the basic guideline for the research design and to select and justify the appropriate research methods to collect and analyse the data. Therefore, the fieldwork phase involves applying AGT method to collect, analyse and structure the empirical data from Megaproject experts on using CMMs to manage and mitigate MCRs. In the post-fieldwork phase, the empirical findings on each CMM were discussed and compared with the literature review to design and develop mitigation measures proposals for MCRs, which collectively form the development of proposed approach to risk management of Megaprojects.

The proposed approach is robust and unique in that it comprises for the first time a combination of practical mitigation measures (ACT, PMO, COP and NFC) for MCRs. It is suggested that the ACT accommodate provisions allowing compensation to cover the costs associated with non-commercial risks that have significant impacts on Megaproject performance. The ACT also includes a legislative exemption mechanism to increase the adaptability of Megaprojects to legislative and policy changes. The PMO is suggested as a national governance authority to provide strategic oversight on the delivery of Megaprojects by developing and administering a specific COP for the Megaprojects context. The COP is suggested as a comprehensive and dynamic document to be followed by Megaproject developers and their supply chain to ensure they are equipped with best practices, processes and procedures to plan and deliver their Megaprojects in the best way. Finally, the NFC is suggested as a mitigation measure to overcome the weaknesses associated with the existing contract systems in the Megaprojects context.

Delphi validation technique was applied to ascertain the logical soundness, completeness, accuracy and acceptability of the elements of the proposed approach (ACT, PMO, COP and NFC). It was also used to check the practicality of the proposed approach in the UK context, and whether it is effective to manage and/or mitigate MCRs in a better way. The Delphi validation process involved three rounds of semi-structured interviews with the Megaproject panel of experts. The findings of each round were audio-recorded, transcribed, summarised and reflected in the original design of the proposed approach until the consensus among the experts was reached in Round 3.

The Delphi results confirm that the elements of the proposed approach are viable measures which can provide practitioners with a structured methodology to identify, manage, and mitigate MCRs in a better way in the future. Therefore, the proposed approach should be viewed as an essential component within any holistic and proactive project risk management task for Megaprojects. By no means is this the definitive approach for managing all Megaproject Risks (MRs). It does, however, specifically aim to equip sponsors, clients, operators and practitioners with concrete mitigation measures to manage and mitigate elements of most MCRs deemed crucial for Megaproject success. Hence, the proposed approach can be applied consistently across all Megaprojects and only Megaprojects. Until now, there has been no such comprehensive approach; this research study is the first to attempt to do this.

The proposed approach represents a paradigm shift to the traditional way of managing risk in Megaprojects towards a structured and realistic methodology tailored to their scale and complexity. The proposed approach also represents a significant contribution in turning uncertainties associated with MCRs into well-understood, manageable risks, which can improve the delivery performance of Megaprojects that may not otherwise be achievable through conventional risk management approaches.

The research study concludes that the proposed approach can systematically provide better and more realistic cost and time estimates for future Megaprojects.

Accordingly, the proposed approach has the potential to reduce cost and time overrun in such projects. Owing to their scale, saving a small percentage of a multi-billion dollar/pound Megaproject is far more significant than saving a larger percentage of a conventional project. Therefore, the proposed approach has the potential to deliver better value for money and affordability to Megaprojects.

The research study contributes to the knowledge by introducing for the first time an original approach to risk management in Megaprojects beyond the conventional approaches. Thus, the current research study succeeds in filling the knowledge gap, which has a significant impact on the whole process of risk management in Megaprojects; hence fulfils the research aim and objectives.

9.3 Research Contributions

The previous sections clearly show that the research objectives set out in Chapter 1 have been successfully achieved; thus, the research aim is accomplished. By accomplishing the research, this research study has provided a significant theoretical and practical contribution to the area of risk management in Megaprojects. Theoretically, the research study has synthesised the existing literature on Megaproject Risks (MRs) and consolidated it into a comprehensive list of 38 MRs that can be used as a resource for both practitioners and academics. Further, the research study has identified, for the first time, a unique list of MCRs with a clear and precise definition. MCR profiles can increase the knowledge and awareness of Megaproject practitioners about the nature of MCRs, hence, help them to anticipate and proactively manage these MCRs. The list of MCRs is not exhaustive, but it is still very meaningful because they occur systematically in all Megaprojects and only in Megaprojects. The research study also provided a new approach to identify MCRs systematically, which can help both academics and practitioners to repeat the procedure and potentially apply it to their studies/projects.

This research study also advances the existing body of knowledge within the application of risk management to Megaprojects. It presents a fresh approach to this topic, which goes beyond the existing conventional approaches by considering the scale and complexity of Megaprojects. The proposed approach is unique in that it comprises for the first time a combination of practical mitigation measures that can be applied consistently to manage and mitigate MCRs collectively. Therefore, the research contributes to the knowledge by presenting a paradigm shift to the traditional way of managing risk in Megaprojects. Accordingly, it advocates for further research on the topic of risk management and Megaprojects. Therefore, it can be argued that the current research study has addressed the knowledge gap since there is a lack of attention given to the identification, management and mitigation of MCRs.

Practically, the research study has developed a new risk management approach, which is tailored to cope with the scale and complexity of Megaprojects. This approach provides practitioners, executives and project managers with practical measures to help them identify, manage and mitigate MCRs with a structured methodology. Accordingly, this can ensure better control over the delivery of Megaprojects. Therefore, the proposed approach has the potential to increase the probability of success in a Megaproject. The other practical contribution of the current research study is the potential of the proposed approach to improve cost and time overrun in Megaprojects. Due to the scale of Megaprojects, saving a small percentage of a multi-billion pound Megaproject is very significant to the project's owner and client. This research study demonstrates that the proposed approach is a feasible alternative to make some savings for future Megaprojects. This research study also shows that the proposed approach has the potential to deliver better value for money and affordability to Megaprojects.

9.4 Limitations of the Research

The research study and its main findings are limited in four ways. First, the proposed approach is designed to suit Megaprojects in the UK context and in countries with similar conditions and circumstances. Second, the proposed approach is quite specific: to manage and mitigate MCRs deemed critical to all Megaprojects and only Megaprojects. Third, the number of experts with broad experience in managing risks in Megaprojects is relatively small compared to conventional projects, reflecting the challenge in approaching and recruiting them within the study period. Further, due to reasons of confidentiality and anonymity, some of the experts could not disclose or discuss information relating to the risk management practices of their organisations. Therefore, it was practically as well as ethically challenging to collect the data required for this research study.

9.5 Future Research

By using the adopted research methodology, the current research study could still go further to enhance the proposed approach if the study duration was longer. Therefore, continuous updating and development of the proposed approach are suggested for future research. This includes developing more detailed proposals for the suggested mitigation measures proposals (ACT, PMO, COP and NFC) by providing more information about their likely structures, operations, functions, funding and commissioning.

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Appendices

Appendix A

The Number of Related Papers in the Selected Journals

Name of Journal	**Number**
International Journal Of Project Management	17
Journal Of Construction Engineering And Management	9
Journal Of Management In Engineering	5
Construction Management And Economics	4
Automation In Construction	3
International Journal Of Managing Projects In Business	3
Journal Of Civil Engineering And Management	3
Journal Of Financial Management Of Property And Construction	3
Engineering Construction And Architectural Management	2
International Journal Of Civil Engineering And Technology	2
International Journal Of Critical Infrastructures	2
International Journal Of Risk Assessment And Management	2
Leadership And Management In Engineering	2
Proceedings Of Institution Of Civil Engineers Management Procurement And Law	2
Project Management Journal	2
Built Environment Project And Asset Management	1
Construction Innovation	1
International Journal Of Construction Supply Chain Management	1
International Journal Of Project Organisation And Management	1
Journal Of Computing In Civil Engineering	1
Journal Of Construction In Developing Countries	1
Journal Of Infrastructure Systems	1
Total	**68**

Appendix B

Identification of Megaproject Risks (MRs) from Literature (17 References)

ID	Megaproject Risk name	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	Total
MR1	Adaptability to design changes				√	√	√		√	√	√	√	√		√	√	√		11
MR2	Adaptability to policy changes	√	√	√	√	√		√					√			√		√	9
MR3	Environmental impact			√	√			√	√	√			√	√		√		√	9
MR4	Financial difficulties		√	√		√		√		√		√	√	√				√	9
MR5	Incompetent contractor	√		√		√	√			√		√	√		√		√		9
MR6	Political or public opposition	√		√	√	√		√		√				√		√		√	9
MR7	Adaptability to influential economic events				√	√		√	√	√				√		√		√	8
MR8	Adaptability to legislative changes	√		√	√	√		√	√							√		√	8
MR9	Adaptability to unforeseen site conditions			√	√				√	√		√	√					√	7
MR10	Incomplete contract	√				√	√				√	√	√		√				7

ID	Megaproject Risk name	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	Total
MR11	Adaptability to unproven engineering techniques			√	√			√					√			√		√	6
MR12	Contractual disputes				√		√			√		√			√	√			6
MR13	Lack of operability								√	√	√	√			√		√		6
MR14	Force majeure				√	√			√	√			√					√	6
MR15	Lack of resources				√			√			√		√		√			√	6
MR16	Aligning stakeholders' expectations		√		√		√	√							√				5
MR17	Lack of management oversight		√										√		√	√		√	5
MR18	Adaptability to inflation rate volatility				√					√			√				√		4
MR19	Adaptability to market volatility		√					√							√	√			4
MR20	Delay in project approvals and permits				√						√		√		√				4
MR21	Inappropriate risk allocation		√				√				√	√							4
MR22	Lack of integration and coordination between key parties			√						√	√					√			4

ID	Megaproject Risk name	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	Total
MR23	Uncompetitive tender	√	√							√		√							4
MR24	Delayed payments									√		√	√						3
MR25	Poor public decision-making process		√		√													√	3
MR26	Adaptability to foreign exchange fluctuation				√					√									2
MR27	Breach of contractual provisions	√	√																2
MR28	Government intervention							√										√	2
MR29	Land acquisition and compensation problem				√									√					2
MR30	Adaptability to changes in tax regulation				√														1
MR31	Adaptability to decrease in revenues																	√	1
MR32	Adaptability to interest rate volatility				√														1
MR33	Adaptability to political instability				√														1
MR34	Contract/Concession termination				√														1

ID	Megaproject Risk name	[1]	[2]	[3]	[4]	[5]	[6]	[7]	[8]	[9]	[10]	[11]	[12]	[13]	[14]	[15]	[16]	[17]	Total
MR35	Adaptability to scaling-up													√					1
MR36	Lack of supporting utilities and infrastructure										√								1
MR37	Unrealistic demand expectations			√															1
MR38	Unsuitable domestic legal framework		√																1

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Appendix C

Description of Megaproject Risks

ID	Name	Description
MR1	Adaptability to design changes	Any change to the scope of the work as defined by the contract documents that occur at any stage of a project due to various causes from different sources and have considerable impacts on the project's outputs.
MR2	Adaptability to policy changes	The adaptability of the project to unexpected changes in policies during the development process that could affect the project outcomes
MR3	Environmental impact	The probability that the project will have adverse environmental impacts beyond its permitted limits and increased liabilities.
MR4	Financial difficulties	The risk arising from the unreasonable financing structure, unsound financial market, difficulty in financing, lack of financial income, high finance costs, or difficulty in obtaining finance on time.
MR5	Incompetent contractor	The incompetent contractor with a shortage of resources and capabilities, low capabilities, and low productivity, which lead to low performance and which cause a delay in completion of the work.
MR6	Political or public opposition	For various reasons leading to the public interest being unprotected and damaged, which, as a consequence, causes political and even public opposition to the risk of the project construction.
MR7	Adaptability to influential economic events	Risks are related to changes in economic indicators that might harm the project, such as the abundance of black swans that apply to infrastructure investment.
MR8	Adaptability to legislative changes	The adaptability of the project to unexpected changes in laws and legislation during the development process that could affect the project outcomes
MR9	Adaptability to unforeseen site conditions	Because of the project site's bad natural conditions, for example, climate condition, existing asset condition, special geographical environment, poor site conditions etc.
MR10	Incomplete contract	The risk of the contract with inflexibility, inaccuracy, vagueness, excessive contract variation, inconsistency, inequitable risk-sharing, unclear division of responsibility, etc.
MR11	Adaptability to unproven engineering techniques	The techniques adopted are immature and cannot fulfil the standards and requirements as expected, or the techniques are of poor applicability, which makes private investors reinvest for technology improvement.
MR12	Contractual disputes	Disputes between project's parties about the work quality of other partners and responsibility for errors made on a project can lead to schedule delays and rising project costs.

ID	Name	Description
MR13	Lack of operability	The effectiveness of the project's facilities in performing with the necessary functionalities as designed upon commissioning, which can be tested at early operation phases.
MR14	Force majeure	Circumstances beyond its control, such as acts of God, natural disasters, war, hostilities, and embargo.
MR15	Lack of resources	Loss because of delay in raw materials, labour, resources, machines and equipment, or energy supply.
MR16	Aligning stakeholders' expectations	This risk represents aligning views, needs, and expectations of the key project stakeholders (both internal and external) at different organisational levels (corporate, strategic business unit, and operational) to deliver the project within the anticipated outcomes and to achieve long-term commercial viability.
MR17	Lack of management oversight	Senior management, either individually or collectively, do not have or fail to apply, the capability and motivations to deliver the expected performance
MR18	Adaptability to inflation rate volatility	The increase in the price level of the commodities, the decrease of purchasing power of currencies, which cause an increase in cost and other consequence.
MR19	Adaptability to market volatility	The actual market competition of the existing project caused by the new project or rebuild project of government or other investors.
MR20	Delay in project approvals and permits	Complicated procedures are required for project approval with the high cost and long time. Upon approval, it is very difficult to proceed with business adjustments regarding the project scope and nature.
MR21	Inappropriate risk allocation	Inadequate risk assignment and distribution of responsibilities among the project's stakeholders/parties, which can raise the costs of capital as well as tariff levels in the investment.
MR22	Lack of integration and coordination between key parties	The probability that separate bodies were acting as sponsor, developer (or client) and the operator will not work in synergy. Lack of a robust governance structure
MR23	Uncompetitive tender	Lack of competitive tendering, generate a low number of bidders, which might be unqualified with a shortage in resources and low capabilities, which in turn lead to low performance and which cause a delay in completion of the work.
MR24	Delayed payments	The project might be delayed or slowed down due to late payments from the client, which might give contractors problems because payments are the main source of cash flow for the contractor.
MR25	Poor public decision-making process	The government makes wrong or poor decisions owing to non-standardised procedures, bureaucracy, lack of knowledge or interest, insufficient preparation, weak and/or corrupt institutions and information asymmetry,
MR26	Adaptability to foreign exchange fluctuation	The risk of the variability of foreign currencies exchange and the foreign currencies exchangeability risk.

ID	Name	Description
MR27	Breach of contractual provisions	The failure of one or more party, without legal excuse, to perform its obligations that form all or part of the contract to maximise the benefit.
MR28	Government intervention	Government officials intervene in the project operations directly, which will affect the autonomy of the client's decision-making.
MR29	Land acquisition and compensation problem	The acquisition of private land by a government party for industrialisation, development of infrastructural facilities or urbanisation of the private land, and provides compensation to the affected landowners and their rehabilitation and resettlement.
MR30	Adaptability to changes in tax regulation	The change in tax regulation of central or local government.
MR31	Adaptability to decrease in revenues	Price of products or services is too high, too low, or inflexible to adjust, leading to the revenue of the project company lower than expected.
MR32	Adaptability to interest rate volatility	The loss of the projects arising from the uncertainties of the interest rate volatility.
MR33	Adaptability to political instability	The government's durability and integrity; such a government would not be destabilised by unconstitutional or violent means. This behaviour leads to unstable political consensus behind the project.
MR34	Contract/Concession termination	The probability that the government would be forced to terminate the project's contract or concession and take over the facility run by private firms without giving reasonable compensation.
MR35	Adaptability to scaling-up	The risk associated with the transition of resources, practices, processes, procedures, means and methods, and systems from conventional-scale to massive-scale (Mega-Scale) due to three key dimensions: project scale by any metric, project duration and project complexity.
MR36	Lack of supporting utilities and infrastructure	The risks generated by the unavailability of the supporting facilities of the project.
MR37	Unrealistic demand expectations	Demand risks result from the uncertainty of the demand for the product or service provided by the completed project.
MR38	Unsuitable domestic legal framework	The probability that legal and managerial structures put together to develop and operate the project will not perform well. e.g. weak: land law, procurement law, contract law, planning law, banking law, etc.

Appendix D

Classification of Megaproject Risks

ID	Megaproject Risk	MCRs	Specific MRs	Partially Common MRs
MR1	Adaptability to design changes			√
MR2	Adaptability to policy changes			√
MR3	Environmental impact		√	
MR4	Financial difficulties			√
MR5	Incompetent contractor			√
MR6	Political or public opposition			√
MR7	Adaptability to influential economic events		√	
MR8	Adaptability to legislative changes			√
MR9	Adaptability to unforeseen site conditions		√	
MR10	Incomplete contract	√		
MR11	Adaptability to unproven engineering techniques			√
MR12	Contractual disputes			√
MR13	Lack of operability	√		
MR14	Force majeure			√
MR15	Lack of resources			√
MR16	Aligning stakeholders' expectations			√
MR17	Lack of management oversight			√
MR18	Adaptability to inflation rate volatility		√	
MR19	Adaptability to market volatility		√	
MR20	Delay in project approvals and permits		√	
MR21	Inappropriate risk allocation		√	
MR22	Lack of integration between key parties			√
MR23	Uncompetitive tender		√	
MR24	Delayed payments		√	
MR25	Poor public decision-making process		√	
MR26	Adaptability to foreign exchange fluctuation		√	
MR27	Breach of contractual provisions		√	
MR28	Government intervention			√
MR29	Land acquisition and compensation problem		√	
MR30	Adaptability to changes in tax regulation			√
MR31	Adaptability to decrease in revenues		√	
MR32	Adaptability to interest rate volatility		√	
MR33	Adaptability to political instability			√
MR34	Contract/Concession termination			√

ID	Megaproject Risk	MCRs	Specific MRs	Partially Common MRs
MR35	Adaptability to scaling-up			√
MR36	Lack of supporting utilities and infrastructure		√	
MR37	Unrealistic demand expectations		√	
MR38	Unsuitable domestic legal framework			√

Appendix E

AGT Interview Questions

Categories	Question Type	Question Description
ACT	Fixed	**Q1.** Do you think it is a **viable measure** to legislate and enable a specific Act of Parliament for Megaprojects (ACT)? Why?
	Subsequent	**Q2.** Which elements of MCRs could be managed and/or mitigated under this ACT? Why? **Q3.** What are the essential measures, processes, or actions that need to be included in the ACT to manage and/or mitigate MCRs in a better way? Hence improve the delivery performance of Megaprojects? **Q4.** Could you elaborate more on which sort of compensation the ACT can provide? **Q5.** Could you please elaborate more about what are the main functions of the legislative exemption mechanism and how its work? **Q6.** In which phase(s) of the Megaproject life cycle, this exception mechanism should be applied? **Q7.** Who has the authority to apply the legislative exemption and compensation mechanisms? Why? **Q8.** Do you recognise any limitations and weaknesses with this ACT or its elements?
PMO	Fixed	**Q1.** Do you think it is a viable measure to create a Project Management Office (PMO) at the national level for Megaprojects? Why?
	Subsequent	**Q2.** Which elements of MCRs could be managed and/or mitigated under this PMO? Why? **Q3.** What are the essential functions and responsibilities of this PMO to manage and/or mitigate MCRs in a better way? Hence improve the delivery performance of Megaprojects? **Q4.** Could you please elaborate more about how the PMO strategic oversight function do? **Q5.** Could you please elaborate more about how the PMO develop and mandate a specific COP? **Q6.** What are the resource requirements for developing this COP? **Q7.** How do you think the PMO should be interacting with existing authorities in the UK like NIC or IPA? **Q8.** Do you recognise any limitations and weaknesses with this PMO or its functions?
COP	Fixed	**Q1.** Do you think it is a viable measure to develop specific Code of Practice (COP) for Megaprojects? Why
	Subsequent	**Q2.** Which elements of MCRs could be managed and/or mitigated under this COP? Why? **Q3.** Could you elaborate more about what should be coded in order to manage scaling-up?

Categories	Question Type	Question Description
		Q4. Could you elaborate more about the involvement of senior operator team at early appraisal stages? **Q5.** Could you explain the development process of this COP? How and by whom? **Q6.** What are the resource requirements for developing this COP? (data) **Q7.** Do you recognise any limitations and weaknesses with this COP or its elements?
NFC	Fixed	**Q1.** Do you think it is a viable measure to develop a New Form of Contract (NFC) specifically for Megaprojects? Why?
	Subsequent	**Q2.** Which MCRs or its elements could be managed and/or mitigated under this NFC? Why? **Q3.** What are the essential features of this NFC to manage and/or mitigate MCRs in a better way? Hence improve the delivery performance of Megaprojects? **Q4.** Could you elaborate more on what is needed for NFC to be more flexible and adaptable to the incompleteness of Megaprojects? How? **Q5.** Could you elaborate more on the management of interfaces in the NFC? **Q6.** Could you elaborate more on modelling collaborative behaviours in the NFC? **Q7.** Could you elaborate more on incentivising shared outcomes in the NFC?

Appendix F

Transcriptions of AGT Interview Questions

Theme	No.	Question	Transcriptions
ACT	**Q1.**	Do you think it is a viable measure to legislate and enable a specific Act of Parliament for Megaprojects (ACT)? Why?	**[E1 – E28]** • Yes, I suppose it is viable measure since there is no such Act of Parliament that can be applied explicitly for all Megaprojects in the UK, instead each Megaproject has its Act of Parliament as Crossrail Act 2008 or High Speed Rail 2 (HS2) Act 2017. E3 • I think there is a need for a specific Act of Parliament with elements similar to the concept of PPP Acts/Law in other countries like France, Ireland and Poland to facilitate the delivery of Megaprojects by creating a stable delivery environment. E4 • I think such Act of Parliament is necessary for all countries … if you look to the UK context, one of the success factor of the 2012 Olympics was that there was an Act of Parliament and there were certain things that were built into this Act of Parliament that allowed for thing to be speeded up. E6. • All Megaprojects will to a high or less extent be influenced by governments, where civil servants, tend to keep options open in terms of policies and regulation, so yes I think it will be worthwhile to have such Act of Parliament to stabilise the delivery environments of Megaprojects. E8
ACT	**Q2.**	Which elements of MCRs could be managed and/or mitigated under this ACT? Why?	**[E1 – E11]** • The Act of Parliament can provide provision to deal with non-commercial risks such as change of law … I presume the Act of Parliament would say the impact of such change of law is outside the scope project contracts. E2 • I subsect if we had such ACT, legislative changes would possibly be alleviated … I can give you an analogy .. when I started my position in this oil and gas Megaproject, there was no consideration of global warming .. all environmental impact was around oil spill, which is been taking seriously…so in oil exportation you don’t worry about carbon footprint, which is now in many parts of the world consider it as a big issue because I think that it depends on society who decided that we don’t want global warming .. such Act of

Theme	No.	Question	Transcriptions
			Parliament would make the government aware of such trends and protect the clients of Megaprojects from its implications. E3 • I think such a mechanism can reduce the opportunities for corruption substantially, because every change in law, and every change in regulations, is an opportunity for corrupt government officials to exist. So we swapped away many opportunities for corrupt officials. E6 • I think it is necessary to have within this Act of Parliament some measures that would increase the adaptability of law changes and adaptability to policy changes. E7 • Our project fails to adapt to changes in the law including health and safety legislation and regulations within the office of rail and road regulator .. so I think this Act of Parliament is principal is that it gives some protection against such legislative changes. E10 • I think the length of Megaprojects is so long that many legislations can be changed over time .. therefore so you really need to be aware of such changes as far as possible and try to stay ahead of the theme.. therefore, I would say the Act of Parliament may be useful to handle such changes. E11
ACT	**Q3.**	What are the essential measures, processes, or actions that need to be included in the ACT to manage and/or mitigate MCRs in a better way? Hence improve the delivery performance of Megaprojects?	**[E5 – E10]** • I think such Act of Parliament needs to have clauses that make it clear that some protection needs to be provided by high authorities to exempt Megaprojects from the implications of unexpected changes in legalisations and/or policies. E5 • I suggest the Act of Parliament needs to have measures in place which can be used to compensate private party and commissioners of Megaprojects for additional costs/and expenditures imposed as a result of legislation changes by the governments. E7 • It seems that the Act of Parliament should outline the circumstances in which compensation may be appropriate for those how could be affected by unexpected changes in government policies and similar actions. E8 • Concerning the adaptability to the law change, usually there is always sufficient protection in the agreement to handle changes in-laws, so the optimism buyers to come from local law changes that have not been well covered in the original contractual agreement. E9 • In my view, the Act of Parliament needs to define a mechanism that could include an adjustable portion in service fees to compensate for bylaw changes. E10

Theme	No.	Question	Transcriptions
ACT	**Q4.**	Could you elaborate more on which sort of compensation the ACT can provide?	**[E7 – E12]** • Typically, this kind of strategic risks (adaptability to legislations and policies change) covered by the client …. So if you are in a big project, there is always money for legislative risks change, political change, environmental changes … these risks are part of every big program, and there is always some of moany assigned to them, so when these things happen, contractors always put a compensation event to renegotiate the contract positions are always the client except that. I think this kind of compensations could be accommodated within the ACT. E7 • The Act of Parliament as I suppose can expressly establish the right of compensation for uncertainties in-laws, policy, and regulation which arise over during the delivery of Megaprojects. E8 • I would say the Act of Parliament and its mechanisms should also provide a practical procedure to obtain a governmental guarantee for extending the concession period and milestone dates of the project as a compensation measure for unanticipated legislative and/or political changes. E9 • I would suggest that the Act of Parliament should clearly state that any delaying effects on the project schedule and/or cost escalation resulted from changes in governments need to be compensated by extending the construction period, the concession period, or both. E10
ACT	**Q5.**	Could you please elaborate more about what are the main functions of the legislative exemption mechanism and how its work?	**[E5 – E16]** • With such Act of Parliament, you can also insulate Megaproject from any expropriation action, but you need to define those precisely. E5 • A mechanism needs to be accommodated and defined with this Act of Parliament to insulate private funding assets from policies change … for example, you can currently pass a law under the exiting conservative parliament to say that HS2 and any private funding assets will be insulated over a certain period of time from any loss due to any changes to a particular bylaw … that only what you could do because you couldn't tide the hand of the next government from not nationalising that Megaproject. E6 • The mechanism can allow for suspending compliance with changes in laws, policies, and regulations for a defined period to reduce the turbulence that could result from instant compliance. E7 • For regulation put all formality around what the submittal look like, has had a consultation, have to be face-to-face or call, or the public meetings, of these detailed, come out regulations, the law would establish the principles, regulation the mechanisms. E9

Theme	No.	Question	Transcriptions
			• I'm of the opinion that the mechanism could provide some flexibility and protection at the same time against certain perceived risks by allowing Megaprojects to temporarily suspend their compliance with some a pre-defined list of legislations. E10 • I think that such Act of Parliament needs to make a national principle that the local jurisdictions would have to justify a particular change is necessary either to protect health and safety or to accomplish the objectives of national change of law for which the projects itself was not explicitly exempted. E11 • Well, I see things rather differently as I think in order to apply such mechanism, your project needs to reach a reasonable level of maturity and certainty, which are essential for the project team to precisely identify which piece of legislation or policies that could affect their projects. E12 • It seems to me that Megaprojects team probably would need to reach out to the local authorities, understand how they might change the law either because of their project or just in general and assess the potential impacts of those changes when it happened on their project. E13 • I also think that the project team maybe get these local authorities and relevant bodies to concur with those impact, for example, by saying yes that is a reasonable assessment with the impact would be. E13 • Taking the HS2 perspective, the project started through a Hybrid Bill process to get Royal Assent, and there were already 1500 people working on the project …so it is difficult to rush the parliamentary process. E14 • The mechanism may also provide legislative deferrals for specific legislation. E15
ACT	**Q6.**	In which phase(s) of the Megaproject life cycle, this exception mechanism should be applied?	**[E12 – E16]** • Any changes of the national laws unless exclusively excluded by the Parliament will only apply to project initiated after the enactment of the law. By doing this, you also protect the national significance of the change and strategic interest of that law. It will include a test in the Act of Parliament consider whether this changes should be broadly applied because it is within the broad interest, or should be specifically be applied to project more narrowly represent the national interest. So another way to provide a guide to the Parliament to exempt or not exempt the implication of law changes. So the Act of Parliament can provide some protection. E12 • I would suggest that the mechanism could exempt Megaprojects during the implementation and/or operation phases from changes in policies, laws, and regulations for a defined period of time. E14

Theme	No.	Question	Transcriptions
ACT	**Q7.**	Who has the authority to apply the legislative exemption and compensation mechanisms? Why?	**[E17 – E22]** • Legalising and enabling the Act of Parliament is generally located within the sponsor-governmental level like the Department of Transport .. because the government is the party best able to deal with this sort of risks … whereas our origination like HS2 does not have a way of controlling such risks. E17 • The governmental authority because they only have the authority and capability to propose and develop such statutory instruments .. again, this example of risks need to be pushed to the government. E18 • Well .. I think such a mechanism needs to be commissioned by a commissioner who has both the capability and the authority to assess whether a project should be exempted from particular legislation. E19 • From my perspective … the commissioner of this mechanism should be able to assess the impact of the change of local laws … you recommend doing cost-benefit analysis within your framework to the project from a change of law. E20 • I think the government should give full responsibility for political and legal risks … if the government and high authorities take these risk seriously, I think the delivery performance of Megaprojects will improve … but unfortunately, governments were too busy dealing with other stuff. E21 • This was necessary because our project company does not have the ability and capability of controlling such risks, and that is the example of risks that need to be pushed to the sponsor. E22
ACT	**Q8.**	Do you recognise any limitations and weaknesses with this ACT or its elements?	**[E20 – E28]** • The Act of Parliament is a very complicated thing to achieve … it could take many possible years …. once you had it in the place, it will be difficult to change, and also so vague to be interpreted. E20 • The protection against changes in-laws can be provided by the sanctity of contract, which means that the Law Courts (being independent of the government in a developed country like the UK) will uphold the contract against the government, if necessary. E21 • The national law cannot be restricted by such a legislative exemption mechanism, whereas the local law (Byelaw) could be… I suspect the national law takes precedence over the local laws, and I think the national law put a restriction on the local law with respect to these very special projects. E22. • I would be very careful in having such an authority examine Megaprojects from national or local law based on their interest, because of the issues of sovereignty. E24

Theme	No.	Question	Transcriptions
			• As a practitioner, that is a great idea, I would absolutely like and appreciate to have an Act of Parliament, and I know that my project is insulated. However, the question is, are the legislators actually willing to do that? Because they tie the hands of future parliaments, and normally most governments, when they come to something like that, they are very careful not to restrict the ability of the government to do that. E26 • I can see the value for the Act of Parliament and its exemption mechanism because I can see that local planning measures that have been introduced nationally have an impact caused programs. However, you need to be careful, because If the government decided to band diesel vehicles because of the impact of particle emissions on health and environment, how that impacts the financing model for rail projects? So you will end up with something too difficult to be right. E28
PMO	**Q1.**	Do you think it is a viable measure to create a Project Management Office (PMO) at the national level for Megaprojects? Why?	**[E1 – E28]** • My impression is that there are several barriers limiting boards' strategic oversight for Megaprojects not only in the UK but in the globe, including the lack of resources and expertise. E1 • From my point of view, major projects and programs are commonly affected by a lack of the right capabilities and skills … this is especially the case in public sector organisations at the national level .. so I would say there is a room for improvements I guess. E2 • I strongly believe that there is a need for a pool of resources of expertise and experience at the national level to deliver this sort of projects. E3 • In my experience, typically, people who are making Megaprojects tend to make assumptions that everybody who has done large projects could do major programmes or Megaprojects and that's not true .. instead, they need to be very careful when it comes to select experts to do Megaprojects and similar programmes .. such experts need to understand what they are doing and to be realistic and have had significant experience and expertise in all sorts of projects, because otherwise they will be optimistic and they will not be able to solve and handle major risks. E5 • Yes .. I am saying there should be capabilities on that board to make sure that your management team do the right thing. E6 • We already have the Infrastructure and Projects Authority (IPA), which is fundamentally an internal public sector advisory body … however, its advice does not have to be followed by public bodies undertaking Megaproject .. furthermore, it is also a relatively small team which is thinly spread across a wide canvass

Theme	No.	Question	Transcriptions
			of projects …and it does not necessarily possess all the project development and delivery skills in sufficient depth… however, it has some very good people and power by virtue of being located in the Cabinet Office … so to be more effective, it would need to be given a more transactional mandate and given more resources .. this justifies a national governance system for Megaprojects in the UK. E9 • I see your point … moreover, that's why in my opinion having a group like a centralised PMO who could establish and implements best practices and maintains standards related to Megaprojects is very important. E12 • Sometimes the UK creates a statutory PMO called a Development Zone, Development Agency or Development Authority … Doing this requires an Act of Parliament … This development zone/agency/authority will have a budget to invest as well as special project development and planning powers. This model has been very successful. It is an interesting question as to why this model is not used more often in the UK, as it clearly works well? … I think the idea of a "national PMO" is very different. E16 • The key to this is getting the right people, and that is not a science is an art, and if you don't get the right people when you get to realise that replace them, so yes I would recommend having a central pool of expertise for Megaprojects. E17
PMO	**Q2.**	Which elements of MCRs could be managed and/or mitigated under this PMO? Why?	**[E1 – E10]** • The role of the PMO as the main facilitator and coordinator of the project can help all stakeholders to identify, articulate, and communicate their needs as (strategic objectives) clearly. E2 • Managing politicians and expectations is probably almost the most important thing the PMO can do in the first year of a Megaproject. E5 • In my opinion, the PMO doesn't have to take sides, and it is only interested in getting the programme done… so it's neither owner nor contractor, so it can facilitate the discussion by bringing together all of the stakeholders, so they all get to talk to each other, and the PMO can create an environment of problem-solving rather than a finger-pointing environment. E6 • In our project, as the PMO office, we created a programme management group at different six programme management contractors, and we put a structure in place so we could scale-up everything we want to do. E8

Theme	No.	Question	Transcriptions
			• As a PMO, what we did in our project, we got the operator involved from the beginning to build our documentation on the maintenance platform, so when we got done with construction it automatically turned over to the operator… this was because the operators were involved when we were doing everything from the outset, so the operator team had total information about everything such as equipment, training required, and parts list etc. E8. • I think aligning stakeholder expectations is one of the major risks that could be handled by this PMO since it can provide as a coordinator better directions towards the engagement of stakeholders from the outset. E10
PMO	**Q3.**	What are the essential functions and responsibilities of this PMO to manage and/or mitigate MCRs in a better way? hence improve the delivery performance of Megaprojects?	**[E6 – E12]** • I think the PMO will help us to improve the delivery of Megaprojects by institutionalizing organisational processes and methodologies. E6 • I'm of the opinion that the main role of the PMO would be to provide a strategic oversight by planning, to coordinate and monitor the delivery process of Megaprojects, this eventually could help to achieve the organisation's financial and strategic goals. E7 • The value of PMO when you have competent people, so they can help guide the decision-maker in making the right kind of decisions about both get it they do. E8 • I think the functional centralised PMO is initially to set up processes and systems to make sure to follow it. Now when you get to the project level depend on the project is each project is different, every project may need a different form of PMO to set up, so I think, the PMO should be tailored to each of the projects. E10 • It is not their function to run programmes and Megaprojects… the centralised PMO function really is to make sure you are setting the process controls and best practices that should be followed when the PMO is set up at the project level, and there should be an auditing process to make sure these processes and systems are followed. E11
PMO	**Q4.**	Could you please elaborate more about how the PMO	**[E10 – E18]** • I think the PMO is an essential party for ensuring and maintaining a strategic line of oversight for Megaprojects. E10

Theme	No.	Question	Transcriptions
		strategic oversight function do?	• The role of the PMO is like the leader of the band, so you work with all people who are involved because they all have a different view of what has been done, so bringing them together, so everybody understands all the roles and responsibilities of all the entire team. Everybody clear from the beginning who does what. E12 • The PMO is going to monitor project and programme … therefore the information they need has to be supplied… for example, if the PMO wants to measure the earn value formation of all project and programs, in the draft framework has to say, suppliers must provide and report back earn value information. E13 • Personally, I think that should be one mechanism, the PMO should advise Megaprojects and big program on how to do things … so the PMO could set up and create systems and processes about practices and afterword audit these projects to make sure that people following them. E16 • The PMO from a national perspective should be set up to make sure the best practice are being wrought and been set up and being followed and necessarily implementation. E17 • I don't think really there is a bias … Megaprojects need to follow the best practices … the role of PMO is to communicate these practices and expectations to follow them … however, their main job is to update these practices processes because some of them will not work probably over time, so their job is to centralise the best practices to make sure to follow them. E18
PMO	**Q5.**	Could you please elaborate more about how the PMO develop and mandate a specific COP?	**[E10 – E18]** • The bottom line the PMO could develop a standard or code of practice for Megaprojects that should layout best practices and layout how parties are expected to deal with each other, but should probably define some minimum requirement for stage gates for example. E10 • Well, I'm not so sure about whether the PMO should develop and/or mandate a specific code of practice for planning and delivering Megaprojects, however, I think it is a good idea to put best practices for Megaprojects into a standard and allocate the responsibility to follow such standard within the PMO. E12 • If the PMO come up with a new thing, then the code of practice has to change … so you need to update the code every time the PMO come up with something new. E13 • It is generally accepted that the code of practice could be developed by industry, in conjunction with government … however, personally, I think your PMO could play an essential part in the development process of such code. E15

Theme	No.	Question	Transcriptions
			• You need to bear in your mind that best practices could be codified and replicated to provide guidance for those working in construction projects … the issue with the environment of these major programs is they are very uncertain and complex .. I suggest these programs would really need a lively code of practice, which could be developed and updated regularly by a central authority at the national level. E16 • Megaprojects are promoted and delivered within a continually evolving delivery environment, which is challenging to reflect in a constant code of practice. E17 • If you keep your code of practice generic by saying that the PMO will do whatever, then you will leave the room for uncertainty, unless you are specific, describe what the outcomes are. E18
PMO	**Q6.**	What are the resource requirements for developing this COP?	**[E16 – E22]** • I would like to point out that to develop a code of practice for Megaproject, the PMO should be provided with useful data to capture the dynamic nature of Megaprojects … I would suspect lack of providing such data will result in the impossibility of developing a rigorous code of practice similar to what you are proposing. E16 • I would suggest looking to the IPA databases … they are looking to make delays due to the different aspect (legal or regulatory aspects) … the data could be gathered from official or industrial one because both of them are fine. E19 • Well, that's possible,… however, the PMO needs to be supplied with high-quality data from different sources and from different levels .. this might include corporate level, industrial level, and project level. E20
PMO	**Q7.**	How do you think the PMO should have interacted with existing authorities in the UK like NIC or IPA?	**[E19 – E24]** • It is a quite healthy practice to share data and lessons from the existing bodies in order to minimise the level of conflict because such bodies could impose their own code of practice on Megaprojects as a condition of development during the early conception phase. E19 • Sure, that's one way of optimising the resources … I would suggest that the PMO could engage with the departments of the UK government and the existing related authorities to identify and develop best practices, processes, and procedures that promote early engagement of project stakeholders. E22 • To avoid conflict .. I suggest that the IPA could be part of the PMO that provides best practice and expertise. E23

Theme	No.	Question	Transcriptions
			• NIC, they advise the government on what not how – should we investing Hyperloop … we invest in the road charging, and I don't think the NIC should act as PMO … what I think instead, the PMO could engage with the NIC to reflect their visions in the code of practice. E24
PMO	**Q8.**	Do you recognise any limitations and weaknesses with this PMO or its functions?	**[E24 – E28]** • I am a very strong believer that this PMO will add another layer of bureaucracy in the system, ….. instead, it is better to build on what we already have. E24 • I'm not sure I go along with the view that the establishment of a PMO is essential for Megaprojects in the UK since such a measure will increase the level of bureaucracy and complexity. E25 • Having this PMO, there will be jealousy between the various civil service departments… if you look, for example, to the Department of Transport, it has people who would consider themselves to be the PMO within the department looking after HS2, Thames Link, Crossrail 2…. I think this could happen in other departments … therefore, as far as I'm concerned, the PMO needs to interact with the UK departments collaboratively. E26
COP	**Q1.**	Do you think it is a viable measure to develop specific Code of Practice (COP) for Megaprojects? Why	**[E1 – E28]** • I would say probably yes … since the existing codes of practice tend to focus on contingencies rather than managing risks. E2 • The existing risk management processes and procedures are fairly well defined …. however, the key issue is they have the tendency to focus on the contingencies rather than on the risk management and mitigations .. therefore developing a specific code of practice to address and fill this gap is essential. E3 • The existing British Standard doesn't differentiate between Megaprojects and small projects, and I think there is a need for a British Standard specifically for Megaprojects… I totally agree with having a special one for Megaprojects, and I think we should have it. E5 • There is a lot of expertise and know-how across the industry and in people's heads on this, but I am not aware of it being written down and codified yet as 'best practice'… I think it could be useful if it were codified and then shared across the industry internationally. E6.

Theme	No.	Question	Transcriptions
			• I have to side with you on this one that the people are not using the tools effectively, and at the same time, I disagree with the fact that there are a lot of tools only focusing on managing risks rather than on managing not getting into the risk for Megaprojects. E7 • I think there's a benefit of having something could drive best practice for Megaprojects so that you need to follow these principles or you need to do this all you need to adopt this code of practice and the other practice has flexibility on it. E8 • Stop telling people what to do, and provide them with the standard information to make decisions and to take responsibility… and give them the authority to exercise their responsibilities. E10.
COP	**Q2.**	Which elements of MCRs could be managed and/or mitigated under this COP? Why?	**[E1 – E10]** • In my opinion, it depends on what you are trying to achieve from such code of practice … giving a code of practice on organisations, how you do governance, and have you do assurance, you do risks, how you do performers and procurements, there is a huge amount of disciplines over there. E1 • There will be a list of things that the code would ask for, and then you would look at who does that where that set, and if it set in with the supply chain, that requirements have to get into the contract. E3 • I think a code of practice is an interesting idea and should include things like governance, management, approval processes, resourcing, quality control, stakeholder consultation, market engagement, procurement strategy and contracting strategy. E4 • I think the principle that you should consider is scaling-up risks should be allocated to the parties best placed to manage them … although this principle could apply to both large and small projects, hence you need extra guidance and attention in the context of very large scale projects like Megaprojects. E5 • I think the lack of operability is one of the main aspects of Megaprojects that need be codified and mandated because such risk is a major threat that causes Megaprojects to go wrong, which eventually tend to threat both project and organisation viability alike. E8 • Sometimes the operational reality is different from the operational theory because the people who designed it did it from a textbook and haven't got the actual practical experience. E10

Theme	No.	Question	Transcriptions
COP	**Q3.**	Could you elaborate more about what should be coded in order to manage scaling-up?	**[E5 – E12]** • So whatever you putting the code of practice, if you start with this with the basic principles, but thinking about the stakeholders, thinking about broader impact, thinking about scalability, among a list of things you need to think about maybe one of the most essential aspect of the code of practice, getting into detail and construction. E5 • When things become large, they don't necessarily become difficult for Megaprojects to deal with… the one that needs special attention is when it gets to a certain level of complexity and uncertainty or both; then I think it is actually unordinary so you need do something at a different level of project management and codify it. E6 • Manging scaling-up in Megaprojects is very critical for the client .. take the supply chain as a good example …. the amount of concrete or steel used in the small projects has no impact on the market whereas if you have a Megaproject that could actually impact the supply and demand, therefore when you doing costing you cannot just take the marketplace, you have to analyse whether your project is going create scarcity, you also have to analyse there might be several Megaprojects running at the same time, so you have to think about how to phase them … all of these issues code be codified. E8 • I think the code of practice needs one ward (think), you need to make sure how this word involved in the planning of Megaprojects by taking into considerations all the angles and what the project would be involved as widely as possible. Then all of these issues will be covered. Often one goes wrong with Megaproject is when you have a project leader that it is not consultative thinks they know best how to persuade visions, and then misses some angles because nobody is perfect. E9 • I would accommodate three aspects in this code of practice … the scale itself is controllable and manageable, I think the duration similarly is controllable and manageable, and I think the complexity is only partially controllable. E10 • We can control the scaling-up if we not only better understand the assumption we made and track these assumptions over time .. we can better control the impact of the scale and duration, either by standardise the construction, at least standardised the details of construction. E11

Theme	No.	Question	Transcriptions
COP	**Q4.**	Could you elaborate more about the involvement of senior operator team at early appraisal stages?	**[E5 – E12]** • If you want to develop a business case for a railway project it is not good enough having only construction skills and development skills; instead, the business case developer needs operator skills as well... in fact, it is a fundamental action to have operator expertise and skills to expand the concept design of a project. E5 • I think operation and maintenance are a key concern for Megaprojects, and I think there is a particular risk area, where Megaprojects by very nature are experimental and therefore fail with maybe undesirable outcomes. E6 • Normally, people who specify the project are often a combination of users and government (who are paying for the projects) and engineer (who design the project) … however, very often, people who actually have to do the operation are not involved in the team; accordingly, some of the operational issues will not be thought about. E7 • It will be a complex and challenging task if you are running a metro carrying 60,000 people/hr underground, and you have to continue operating while you are upgrading some technology. E9 • Operation is crucially important for Megaprojects to achieve commercial viability…I think there is far too little attention given to establishing the operator from the outset… in fact, people tend to think about the operation at the last minute. E10 • I would suggest that the code should consider the operation of existing Megaprojects … this is because at some stage Megaprojects will probably need upgrading as their assets will either wear out, or they will become commercially unviable; therefore, it will be necessary to modernise them … for example, in the context of the railway a major modernisation project would involve renewing rolling stocks, communication systems, power supply systems and so on, and that is challenging. E11
COP	**Q5.**	Could you explain the development process of this COP? How and by whom?	**[E10 – E18]** • The bottom line the PMO could develop a standard or code of practice for Megaprojects that should layout best practices and layout how parties are expected to deal with each other, but should probably define some minimum requirement for stage gates for example. E10 • Well, my impression is that the code developers need to consider the key principles of the available Laws that are relevant to Megaprojects in order to translate these into practical actions and measures. E11

Theme	No.	Question	Transcriptions
			• Well, I'm not so sure about whether the PMO should develop and/or mandate a specific code of practice for planning and delivering Megaprojects, however, I think it is a good idea to put best practices for Megaprojects into a standard and allocate the responsibility to follow such standard within the PMO. E12 • If the PMO come up with a new thing, then the code of practice has to change … so you need to update the code every time the PMO come up with something new. E13 • I would suggest that the PMO, as the developer of your code, should reflect the best practices, processes, and procedures that are specifically designed and suitable from all Megaprojects and only Megaprojects. E14 • It is generally accepted that the code of practice could be developed by industry, in conjunction with government … however, personally, I think your PMO could play an essential part in the development process of such code. E15 • You need to bear in your mind that best practices could be codified and replicated to provide guidance for those working in construction projects … the issue with the environment of these major programs is they are very uncertain and complex .. I suggest these programs would really need a lively code of practice, which could be developed and updated regularly by a central authority at the national level. E16 • Megaprojects are promoted and delivered within a constantly evolving delivery environment, which is challenging to reflect in a constant code of practice. E17 • If you keep your code of practice generic by saying that the PMO will do whatever, then you will leave the room for uncertainty, unless you are specific, describe what the outcomes are. E18
COP	**Q6.**	What are the resource requirements for developing this COP? (data)	**[E16 – E22]** • I would like to point out that to develop a code of practice for Megaproject, the PMO should be provided with good data to capture the dynamic nature of Megaprojects … I would suspect lack of providing such data will result in the impossibility of developing a rigorous code of practice similar to what you are proposing. E16 • I would suggest looking to the IPA databases … they are looking to make delays due to the different aspect (legal or regulatory aspects) … the data could be gathered from official or industrial one because both of them are fine. E19

Theme	No.	Question	Transcriptions
			• Well, that's possible,… however, the PMO needs to be supplied with high-quality data from different sources and from different levels .. this might include corporate level, industrial level, and project level. E20
COP	**Q7.**	Do you recognise any limitations and weaknesses with this COP or its elements?	**[E22– E28]** • I'm of the opinion that the problem with all codes of practice is the people don't comply with them. E22 • I think the limitation is the designers of such a code have never really envisaged or experienced Megaprojects themselves. E23 • I think the challenge is keeping enough flexibility in some form of code that looks forward to the future of what might go wrong and doesn't become overly burdened with some bureaucracy that is inevitably going to be broken by the project… so keeping that flexibility, so the people do attempt to be compliant with.. once you've got the flexibility, the other challenge is the interpretation of the code. E24 • I think there is a shortage of qualified personnel in government in planning and delivering Megaprojects … so I assume it will be a challenging task to develop such code. E25
NFC	**Q1.**	Do you think it is a viable measure to develop a New Form of Contract (NFC) specifically for Megaprojects? Why?	**[E1 – E28]** • According to myself, scaling-up conventional contractual practices in Megaprojects represents a creation of uncertainty … therefore you need to have a contractual mechanism as well as an operating mechanism that allow you to address these uncertainties quickly and to keep the project moving. E2 • Again I think in Megaprojects a lot of contracts are incomplete, very difficult to write a contract with cases for all contingencies, and you end up with something, which is so big you can't read it and … so I think you need a good contract. E3 • I can admit that NEC3 has some short falling, but I am not sure to what extent these have been solved or addressed in NEC4. Because NEC4 has a number of tools in it, which help to reduce one of the causes of the miss alliancing because NEC3 is not good with it. E5 • There were some risk and uncertainty which can limit your ability to define everything in the existing contract precisely .. that's because the uncertainty in Megaprojects is very high, look to all things we talked about, you can cover some of this stuff in the contract, but not all … I can see the merit of developing a new form of contract for Megaprojects. E6

Theme	No.	Question	Transcriptions
			• In NEC form of contract which is very dominant in this kind of project and programme, that indicates at which need to be set with the party with the best position settled the best party that able to handle it and deal with it and mitigated … however, in practice there is always inappropriate allocation of risk, so yes you could justify the design of a new contract. E9 • So in simple terms, the current contractual practices don't recognise that you are not contractually obligated to collaborate with the other parties effectively. E10
NFC	**Q2.**	Which MCRs or its elements could be managed and/or mitigated under this NFC? Why?	**[E1 – E10]** • I think the current contract does not recognise the inevitability of change and does not provide mechanisms for fairly dealing with change in Megaprojects .. so I would recommend for a new version of the contract that could address this risk incompleteness. E1 • Again I think in Megaprojects a lot of contracts are incomplete, very difficult to write a contract with cases for all contingencies; you end up with something, which is so big you can't read it and … so I think you need a good contract. E3 • It goes without saying that any risk associated with an incomplete contract could be handled contractually. E4 • I would argue that the incomplete contract could be managed and mitigated better by finding a way into the contract to align the incentives of both the contractor and the client to achieve the same outcomes. E5
NFC	**Q3.**	What are the essential features of this NFC to manage and/or mitigate MCRs in a better way? hence improve the delivery performance of Megaprojects?	**[E4 – E10]** • In the existing contractual arrangement the ability to deal with the frequent changes in Megaprojects has to be understood .. so I would say a sufficient flexibility to accommodate significant change is needed in the design of a new contract .. however, the question is how to create flexibility and adaptability of obvious contractual arrangements to deal with the changes over time and over technical specifications various. E4 • The weaknesses in the existing contract arrangement are standing around the interface between packages of Megaprojects … this because all Megaprojects have a very large scope and long life cycle, so you have to divide them up … you can't deliver it in one package, you have to eat the elephant in the small bites as you can't eat the elephant in one byte. E5

Theme	No.	Question	Transcriptions
			• I also recommend you should go further when you design your contract for Megaprojects as you specifically address the forms of collaborations among the contracting parties, including how claims and disputes will be efficiently resolved. E5 • The contract should start with collaborations principles because a good collaboration should be happening within a reasonable timeframe. E6 • I want to see within the contract an incentivise mechanism for both client and supply chain so they both can collaborate to achieve the same outcomes .. and this required a good definition of the outcomes. E7 • The NEC contract is the only contract that quotes behaviours by stating that all parties need to work on a mutual trust collaboration, but there is no legal action against the parties who might not be following this concept, i.e. it is not legally enforceable, and it's intangible. E8 • Collaborative behaviour is massively important, but it is not easy. E9 • I would recommend modifying the existing contract systems to address both the lack of flexibility and interfaces in Megaprojects, take Crossrail as an example, which is developed in 2005, now we are in 2017 where many things have been changed .. the tender stage took place in 2005 or 2006 where there was a set of assumptions made, over time these assumptions have been changed, which create many interfaces and a lot of changes, and these changes caused an excessive delays and there are commercial consequences. E10
NFC	**Q4.**	Could you elaborate more on what is needed for NFC to be more flexible and adaptable to the incompleteness of Megaprojects? How?	**[E7 – E16]** • I hold the view that the issues of flexibility and adaptability of contracts are inherent in Megaprojects, where the existing contract systems are not able to effectively deal with … However, I have a concern about using fully flexible contact or fully fixed contracts, as neither is the optimal option for Megaprojects. E7 • I believe one of the major issues in Megaproject is the clients have a tendency to include more terms and conditions into their contracts … such practices decrease the level of flexibility, so it needs to change. E8 • The existing contractual arrangements increase the level of complexity and put more restrictions on the evolving nature of Megaprojects; hence, that will increase the uncertainties. E9 • If a government really does want to retain maximum flexibility when implementing a Megaproject, then it should use only short-term contracts and should not use private finance. E10

Theme	No.	Question	Transcriptions
			• Why is there a need for a flexible contract if the client already knows exactly what is going to be built? Instead, the client wants transparency and not to lose cost. E11 • I see the issue more of selecting the right contract model-form for each project of part of each project according to what delivers the best value for money for the sponsor – e.g., crucially, incentives for the most efficient management of risk by the contractor. E12 • We should be selectively flexible on those elements where emergencies might happen, and you can think about value gain sharing, you could call it emergent issue resolution. E13 • In my view, Megaprojects need to be decomposed into a number of packages, where each package could be let with a suitable option … for example, in a road Megaproject that could cost £10 billion, it is possible to have a fixed contract with £70 billion to build most of the elements except for the river crossing or interchanges that go into the city, because those interchanges may vary and not be known at an early stage of the project and it might be subjected to a high political and public debate. Therefore, in this case, for example, 70% of the work could be fixed, and 30% of the work could be based on cost-sharing principles. E13 • When building the Channel Tunnel between England and France, we used three different contract price regimes according to what made most sense: (i) above-ground structures such as terminal buildings were built on a fixed-price basis; (ii) the tunnel itself was built on a target-costs basis; and (iii) the rolling stock was procured separately on a semi-fixed price basis. E14 • The same principle selectively flexible contract is currently being used by Mac Macdonald in advancing a major client for a multimillion-pound piece of work because the client, for whatever reason wanted everything to be done within one contract. E15 • A classic example of using a selectively flexible contract can be found in the Ansaldo trains, which were built for Holland, between Holland and Belgium, and there were two contracts, one for the signalling and one for the rail stocks, and due to the poor communication between them there was an interface problem about the equipment rack that was missed…. the fact is the train needed rebuilding even though that was part of the same company. E16

Theme	No.	Question	Transcriptions
NFC	**Q5.**	Could you elaborate more on the management of interfaces in the NFC?	**[E14 – E21]** • I think the existing contract system does not appreciate the level of interfaces between the Megaproject packages, and that is a significant weakness. E14 • The interaction between the packages and contracts is one of the key areas where Megaprojects have a challenge in managing risks .. we call this integration by “overall program integration”, it is the overlapping or glue between the gaps, who is accountable managing that risks. E15 • If you’re going to design a new contract, your design needs to adequately tackle the interface issues in Megaprojects and make them contractually obligated. E16 • The interface is a critical and major risk in a multi-type party contract that has multiple parties delivering independent pieces, and that could be small or large, and that is the definition of the complexity. E17 • One of the distinguishing differences between Megaprojects and conventional projects is purely the scale of contracts with numerous interfaces, which, unfortunately, is not recognised by the existing systems. E18 • The scale of a Megaproject is not only obvious in the scope of the project but also the time .. this is justified because it is very rare to have a Megaproject with a single contract; instead, there is a multiplicity of contracts. E19 • I believe the interfaces depend on how the people responsible for the delivery of a Megaproject chose the procurement strategy, how they break down the contract. E20 • Scope down the work into small packages, and refine the requirements as you know more, and try to know what the interfaces areas you know more, and the integration responsibilities as well. E21
NFC	**Q6.**	Could you elaborate more on modelling collaborative behaviours in the NFC?	**[E19 – E24]** • Although the NEC calls for a spirit of trust and collaboration, the fact is the collaborative behaviours are not contractually obligated in these systems … I would suggest developing a mechanism that could quantify, measure, and evidence the collaborative behaviour among contracting parties. E19 • I think the general level of the intelligence in construction is average at best and when you are talking about psychology and behavioural modelling, understanding the dynamic of the team performance, that is a step up from the level of the intelligence and awareness that you typically see in most contractors and client organisations. E20

Theme	No.	Question	Transcriptions
			• If you get the culture of collaboration right in your organisation, either if you are a client or a contractor, then you instantaneously give a much better sign of success, people are happy, they work together. E21 • What I think, in my opinion, is there’s nothing wrong with the standard form of the contract, it is entirely down to the culture and the behaviours of the organisations that sign up to those contracts, either if they are the client or the contractor or people further down in the supply chain. E22 • I fundamentally disagree with those who blame the contract rather than the selection of the contract … so don’t blame the contract, blame the people who chose the contract … I would suggest a good collaborative behaviour among the contracting parties needs to be modelled at a very early stage. E23
NFC	**Q7.**	Could you elaborate more on incentivising shared outcomes in the NFC?	**[E23 – E28]** • From my perspective, I would criticise the current contractual arrangements with the lack of integration between the client-side and the suppliers' side … this mainly due to the reason that the assumptions on the outcomes made by the client will not be driven and communicated clearly down to the organisations at the bottom of the supply chain. E23 • The existing contract only allows for temporary integration between the client and the supply chain rather than long-term integration. E25 • The contract also should place more requirements on the supply chain tier, one to actually engage their supply chains in the contractual arrangements. E26 • In the London Olympics 2012, a shared-outcomes scheme was applied but only on the tier one level rather than the supply chain. E27

Appendix G

Indication of AGT Interview Questions asked to Megaproject Experts

Theme	No	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25	E26	E27	E28
ACT	Q1.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
ACT	Q2.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓																	
ACT	Q3.					✓	✓	✓	✓	✓	✓																		
ACT	Q4.							✓	✓	✓	✓	✓	✓																
ACT	Q5.				✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓												
ACT	Q6.																	✓	✓	✓	✓	✓	✓						
ACT	Q7.																				✓	✓	✓	✓	✓	✓	✓	✓	✓
ACT	Q8.																												
PMO	Q1.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
PMO	Q2.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓																		
PMO	Q3.						✓	✓	✓	✓	✓	✓	✓																
PMO	Q4.										✓	✓	✓	✓	✓	✓	✓	✓	✓										
PMO	Q5.										✓	✓	✓	✓	✓	✓	✓	✓	✓										
PMO	Q6.																✓	✓	✓	✓	✓	✓	✓						
PMO	Q7.																			✓	✓	✓	✓	✓	✓				
PMO	Q8.																								✓	✓	✓	✓	✓

Theme	No	E1	E2	E3	E4	E5	E6	E7	E8	E9	E10	E11	E12	E13	E14	E15	E16	E17	E18	E19	E20	E21	E22	E23	E24	E25	E26	E27	E28
COP	Q1.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
COP	Q2.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓																		
COP	Q3.					✓	✓	✓	✓	✓	✓	✓	✓																
COP	Q4.					✓	✓	✓	✓	✓	✓	✓	✓																
COP	Q5.										✓	✓	✓	✓	✓	✓	✓	✓	✓										
COP	Q6.																✓	✓	✓	✓	✓	✓	✓						
COP	Q7.																						✓	✓	✓	✓	✓	✓	✓
NFC	Q1.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓
NFC	Q2.	✓	✓	✓	✓	✓	✓	✓	✓	✓	✓																		
NFC	Q3.				✓	✓	✓	✓	✓	✓	✓																		
NFC	Q4.							✓	✓	✓	✓	✓	✓	✓	✓	✓	✓												
NFC	Q5.														✓	✓	✓	✓	✓	✓	✓	✓							
NFC	Q6.																			✓	✓	✓	✓	✓	✓				
NFC	Q7.																							✓	✓	✓	✓	✓	✓

Appendix H

Profiles of Megaproject Experts (AGT Interviewees)

ID	Background	Years of Experience	Interview Type	Location
E1	Programme Director in an underground Megaproject in the UK and Project Development Director at a Governmental Owned Company with more than 35 years' experience in leading programmes of a multi-billion pound.	+35	In-person	UK
E2	Senior Vice President at a major-multinational engineering and construction firm with more than 40 years' experience in strategic management, marketing and operations responsibilities - advising Megaprojects and similar programs totalling $50 billion.	+40	Skype	USA
E3	Head of Planning in a High Speed Railway Megaproject in the UK with more than 20 years' experience in planning and delivering Megaprojects and capital programmes.	+20	Skype	UK
E4	Projects Director in a major consultancy firm in the UK with extensive experience of more than 25 years in planning and delivering transport infrastructure Megaprojects from inception to closeout.	+25	Skype	UK
E5	Senior Director + Global Lead for Project + Programme and Commercial Management in a major consultancy firm in the UK with more than 30 years' experience in developing Megaprojects.	+30	Skype	UK
E6	Senior Managing Director in a multinational professional services company with more than 30 years' experience in planning and delivering Megaprojects and similar programmes.	+30	Skype	UK
E7	Programme Controls Director in a Highway Megaproject with more than 30 years' experience in delivering programmes.	+30	Skype	UK
E8	Chief Infrastructure Officer for a major port in the United States with more than 30 years' experience in operating major-complex problems.	+30	Skype	USA
E9	Head of Programme Controls in an underground Megaproject in the UK with more than 25 years' experience in planning and delivering transportation Megaprojects in the UK context.	+25	Skype	UK

ID	Background	Years of Experien ce	Interview Type	Location
E10	Professor of International Management and Engineering Systems Emeritus at the MIT Sloan School of Management.	+30	Skype	USA
E11	The group president of Fluor's Mining & Metals, Infrastructure, Power, Advanced Manufacturing.	+30	Phone	USA
E12	Senior Finance Adviser in a major professional services network with more than 20 years' experience in corporate and project finance, strategy and policy in the transportation sector totalling of more than $20 billion.	+25	Skype	Australia
E13	A leading Global Infrastructure Executive with more than 30 years of experiences in public Megaprojects & contracting sectors in the UK and overseas.	+30	Skype	UK
E14	Director of the Program Management Office (PMO) of a multi-billion infrastructure reconstruction program with more than 40 years in delivering Megaprojects and slimier programs.	+40	Skype	USA
E15	Senior Director in Global Infrastructure that forms part of major services and property group with more than 30 years in managing large scale infrastructure projects.	+30	Skype	Canada
E16	Senior Projects Director in an industrial deep-water oil and gas Megaproject with more than 30years' experience.	+30	Skype	USA
E17	Investment Programme Director in a Governmental Authority with a wide experience or more than 20 years in the delivery of capital projects, asset development projects, strategic transformational, change programmes.	+20	Skype	UK
E18	Senior Chief Executive in a High Speed Railway Megaproject in the UK with more than 30 years' in planning and delivery public Infrastructure Megaprojects.	+30	Skype	UK
E19	Senior Programme Director in major services and property group with more than 25 years' experience in planning and delivering major projects worldwide.	+25	Skype	Australia
E20	Senior Director of Global Infrastructure at a major professional service company with more than 20 years' experience in planning infrastructure Megaprojects.	+20	Skype	UK

ID	Background	Years of Experien ce	Interview Type	Location
E21	Senior Economist at the European Investment Bank (EIB) with more than 30 years' experience in financing Megaprojects.	+30	Skype	UK
E22	Senior Director in a major construction company in the UK with more than 30 years' experience in delivering Megaprojects around the world.	+30	Skype	UK
E23	Architect and professionally qualified accountant with more than 30 years' experience in strategic businesses, infrastructure Megaprojects, and financial sectors.	+30	Skype + Phone	UK
E24	Chartered Civil Engineer with more than 25 years' experience in the procurement of large scale projects and enthusiasm with NEC Contracts.	+25	Skype	UK
E25	Independent Transportation Professional with interest of application of transport to catalyse sustainable cities and to develop major projects.	+25	Phone	UK
E26	Senior Rail Expert with more than 38 years' experience in the Railway industry in Systems and Operations.	+35	Skype	UK
E27	Member of the NEC4 Contract Board more than 20 years' experience in Megaprojects including Oil and Gas, Railway, Water Treatment, Highways and Building.	+20	Phone	UK
E28	Area Manager in a High Speed Railway Megaproject in the UK with more than 20 years' experience in delivering transportation Megaprojects.	+20	Skype	UK

Appendix I

Ethical Approval Form University of Leeds

Performance, Governance and Operations
Research & Innovation Service
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UNIVERSITY OF LEEDS

Mustafa Majid Al-Shammaa
School of Civil Engineering
University of Leeds
Leeds, LS2 9JT

MaPS and Engineering joint Faculty Research Ethics Committee (MEEC FREC)
University of Leeds

22 April 2016

Dear Mustafa

Title of study **Improving Risk Management in Megaprojects**

Ethics reference **MEEC 15-028, response 3**

I am pleased to inform you that the application listed above has been reviewed by the MaPS and Engineering joint Faculty Research Ethics Committee (MEEC FREC) and following receipt of your response to the Committee's comments, I can confirm a favourable ethical opinion as of the date of this letter. The following documentation was considered:

Document	Version	Date
MEEC 15-028 0. Ethical_Review_Form_V3_Mustafa Al-Shammaa.pdf	4	22/04/16
MEEC 15-028 1. Invitation letter (individuals +organisations).pdf	4	22/04/16
MEEC 15-028 2. Participant Information Sheet.pdf	4	22/04/16
MEEC 15-028 3a. Participant_consent_form.pdf	4	22/04/16
MEEC 15-028 4. Low-Risk-Fieldwork-RA-form.pdf	1	02/02/16

Please notify the committee if you intend to make any amendments to the original application as submitted at the date of this approval as all changes must receive ethical approval prior to implementation. The amendment form is available at http://ris.leeds.ac.uk/EthicsAmendment.

Please note: You are expected to keep a record of all your approved documentation. You will be given a two week notice period if your project is to be audited. There is a checklist listing examples of documents to be kept which is available at http://ris.leeds.ac.uk/EthicsAudits.

We welcome feedback on your experience of the ethical review process and suggestions for improvement. Please email any comments to ResearchEthics@leeds.ac.uk.

Yours sincerely

Jennifer Blaikie
Senior Research Ethics Administrator, Research & Innovation Service
On behalf of Professor Gary Williamson, Chair, MEEC FREC

CC: Student's supervisor(s)

Appendix J

Invitation Letter to Participate in a Research Project (Individual)

Dear (participant's name)

RE: an invitation to take part in a research project

I am writing to enquire if you would be willing to participate in an on-going doctoral research project on improving risk management in megaprojects, which is being undertaken in the School of Civil Engineering at the University of Leeds.

The aim of the research is to develop a better risk management approach for megaprojects. As a senior (project manager, construction manager, and risk manager) you are in an ideal position to contribute to this research by providing valuable in-depth information from your perspective on managing risks that are common to all megaprojects.

The participation involves face-to-face/Skype/phone interview as it is convenient for you and will take (45 – 60) minutes in approximate. The participant information sheet enclosed provides details of the purpose of the study, which you need to consider before deciding whether you would be willing to take part.

The participation in this research will be on a voluntary and consensual basis. Therefore, it will be entirely up you to decide whether or not to take part in this research. If you decide that you would like to participate in the study once you have considered the information provided, please complete and return the enclosed consent form provided.

Please do not hesitate to contact me if you would like to discuss the information provided or ask any questions before agreeing to take part in the study.

I look forward to hearing from you,

Yours sincerely,

Mustafa M. Al-Shammaa

PhD Researcher

School of Civil Engineering

University of Leeds

Leeds, LS2 9JT, UK

Mobile: +44(0) 774 133 1099

Email: ml13mmas@leeds.ac.uk

Invitation Letter to Participate in a Research Project (Organisation)

Dear (organisation's representative name)

RE: an invitation to take part in a research project

I am writing to enquire if your organisation would be willing to participate in the on-going research study on improving risk management in megaprojects, which is being undertaken in the School of Civil Engineering at the University of Leeds.

The aim of the research is to develop a better risk management approach for megaprojects. This research has the potential benefit of understanding the characteristics of common risks in megaprojects, which will enable organisations to manage these risks in a better way. In this regard, participant organisations will be asked to contribute their experience in identifying and verifying risks that are common to all megaprojects.

Participant organisations are requested to nominate two to three individuals from within their organisations who have good experience and expertise in managing risks associated with megaprojects. These individuals will then be interviewed by myself for an hour. Here, I firmly confirm that all information obtained as a result of the interviews will be used to fulfil the research project. All responses will be kept strictly confidential, and all the information obtained as a result of the interviews will remain anonymous, participants will therefore not be able to be identified in any reports or publications. Similarly, the identity of megaproject case studies will be anonymous.

If you do feel that your organisation would like to participate, please use the attached form to send us the name(s) and contact detail of your nominated person(s). If your organisation fell that the nominated person(s) will be coerced to take part in this research, could you please circulate the invitation email to all employees with clear inclusion criteria so that only those eligible to take part can respond. If you have any queries, please do not hesitate to contact me.

I look forward to hearing from you,

Yours sincerely,

Mustafa M. Al-Shammaa

PhD Researcher
School of Civil Engineering
University of Leeds
Leeds, LS2 9JT, UK
Mobile: +44(0) 774 133 1099
Email: ml13mmas@leeds.ac.uk

Appendix K

Participant Information Sheet

Introduction

Dear (participant's name), you are being invited to take part in a research project. This participant information sheet will help you decide if you would like to take part. It sets out the purpose of doing this study, what your participation would involve, the rights and confidentiality of your data, and what would happen after the study ends. Please take the time to read the following information carefully and discuss it with others if you wish. Please let us know if there is anything that is not clear or if you would like more information. Take the time to decide whether or not you wish to take part.

What is Project Title?

Improving risk management in Megaprojects

What is the Purpose?

The aim of this research is to improve risk management of Megaprojects, and hence improve their delivery performance.

To fulfil the above aim, the following objectives are set:

1. Understand the nature of Megaproject Risks.
2. Critical appraisal of risk management weaknesses in Megaprojects.
3. Identify Megaproject Common Risks (MCRs).
4. Develop a new approach to manage and/or mitigate Megaproject Common Risks (MCRs) collectively to suit the UK context.

What is involved in participating?

The participation in this research involves in-depth face-to-face/Skype/phone interview as it is convenient for you to identify and verify the common risks in Megaprojects. It is entirely up to you to decide whether or not to take part. If you agree to take part, you will give us permission to use the information you provide for the purposes of fulfilling this research. You will also be given this information sheet to keep, and you can still withdraw at any time, and you do not have to give a reason.

Once you have agreed to take part, arrangements about when and where the interview will take place will be made. You will be interviewed by the researcher, and the interview will take about an hour. Recording the interview on audio media will be entirely up to you. However, if you prefer not to use audio-recorded, the data will be recorded by taking detailed notes. The questions are about distinguishing Megaproject risks from those associated with conventional projects, identify risks that are common to all Megaprojects, and exploring how these risks can be managed effectively. Questions will enable open as well as closed answers to be given in relation to the topic above.

Confidentiality of the data

I assure you that your response will be kept strictly confidential. Only the research team, including myself, main supervisors, and co-supervisors, will have access to the information you provide. Furthermore, all the information you provide will remain anonymous; you will, therefore, not be able to be identified in any reports or publications. Also, if you agree with recording the interview, the audio recordings of your interview will be used only for analysis. No other use will be made of them without your written permission, and no one outside the research team will be allowed access to the original recordings. I confirm that all information obtained as a result of the interviews will be used for the purposes of fulfilling the research project and can be submitted to journals to support publications.

Thank you very much for taking the time to read through the information and please do not hesitate to contact me if you require further information.

I look forward to hearing from you.

Yours faithfully,

Mustafa M. Al-Shammaa

PhD Researcher

School of Civil Engineering

University of Leeds

Leeds, LS2 9JT, UK

Mobile: +44(0) 774 133 1099

Email: ml13mmas@leeds.ac.uk

Appendix L

Consent Form (Low Risk)

Consent to take part in improving risk management in Megaprojects (Low Risk)	Add your initials next to the statements you agree with
I confirm that I have read and understood the information sheet/ letter dated DD/MM/YEAR explaining the above research project, and I have had the opportunity to ask questions about the project.	
I agree for the data collected from me to be stored and used in relevant future research, or I agree for the data I provide to be archived at [name of archive].	
I understand that relevant sections of the data collected during the study may be looked at by individuals from the University of Leeds or from regulatory authorities where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.	
I agree to take part in the above research project and will inform the lead researcher should my contact details change.	

Name of participant	
Participant's signature	
Date	
Name of the lead researcher	Mustafa M. Al-Shammaa
Signature	
Date*	

*To be signed and dated in the presence of the participant.

Once this has been signed by all parties, the participant should receive a copy of the signed and dated participant consent form, the letter/ pre-written script/ information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be kept with the project's main documents which must be kept in a secure location.

Consent Form (Low Risk)

Consent to take part in improving risk management in Megaprojects (Low Risk)	Add your initials next to the statements you agree with
I confirm that I have read and understood the information sheet/ letter dated DD/MM/YEAR explaining the above research project, and I have had the opportunity to ask questions about the project.	
I agree for the data collected from me to be stored and used in relevant future research, or I agree for the data I provide to be archived at [name of archive].	
I understand that relevant sections of the data collected during the study, maybe looked at by individuals from the University of Leeds or from regulatory authorities where it is relevant to my taking part in this research. I give permission for these individuals to have access to my records.	
I agree to take part in the above research project and will inform the lead researcher should my contact details change.	

Name of participant	
Participant's signature	
Date	
Name of the lead researcher	Mustafa M. Al-Shammaa
Signature	
Date*	

*To be signed and dated in the presence of the participant.

Once this has been signed by all parties, the participant should receive a copy of the signed and dated participant consent form, the letter/ pre-written script/ information sheet and any other written information provided to the participants. A copy of the signed and dated consent form should be kept with the project's main documents which must be kept in a secure location.

Appendix M

Delphi Validation – Round 1

The current research aims to improve risk management in Megaprojects. To achieve this aim, a new approach to risk management is developed based on the opinions and thoughts of experts with rich experience in delivering Megaprojects and similar programs. The proposed approach aims to manage and/or mitigate Megaproject Common Risks (MCRs) collectively in a better way. It consists of four mitigation measures: legislating and enabling a specific Act of Parliament (ACT) for Megaprojects; developing Project Management Office (PMO) at the national level for Megaprojects; developing and mandating a specific Code of Practice (COP) for Megaprojects; and developing a New Form of Contract (NFC) specificity for Megaprojects. The goal of this interview is to seek your opinion and views on the following points:

1. To make sure that the four elements of the proposed approach (ACT, PMO, COP, and NFC) are correctly structured, and their contents and specifications are clear and complete.
2. To make sure that the four elements of the proposed approach are effective and useful to manage and/or mitigate MCRs collectively in a better way.
3. To check the practical applicability and implementation of the four elements of the proposed approach in the real world (UK context) in the future.

In this regards, I would appreciate if you could have a look at Sections 1.1 to 1.4 and prepare some answers for the questions in each section.

Section 1.1 - ACT

The legislative exemption mechanism presented in Figure A1.1 is developed based on the opinion of Megaprojects experts.

Category	ID	Questions
ACT	Q1.	• What are the practical challenges of enabling this ACT in the UK? • Do you think it is structured properly? • Do you recognise any missing element? • Do you recommend any modification that would improve it?

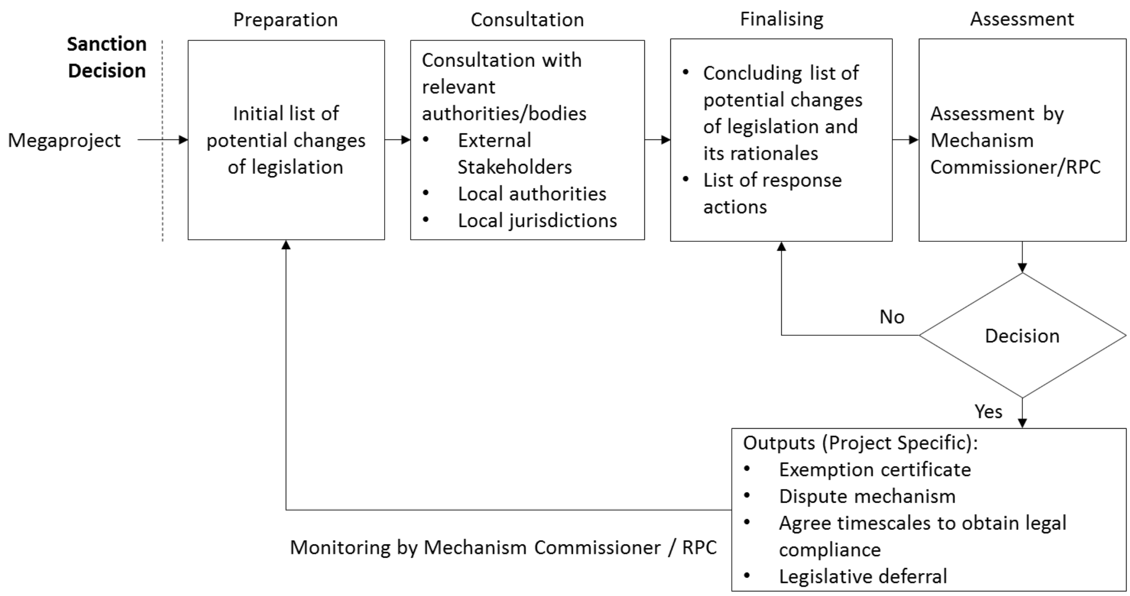

Figure A1.1 Legislative Changes Exemption Mechanism

Section - 1.2 PMO

The governance system presented in Figure A1.2 is developed based on the opinion of Megaprojects experts.

Category	ID	Questions
PMO	Q2.	• What are the practical challenges of developing this PMO in the UK? • Do you think it is structured properly? • Do you recognise any missing elements with this system? • Do you recommend any modification that would improve it?

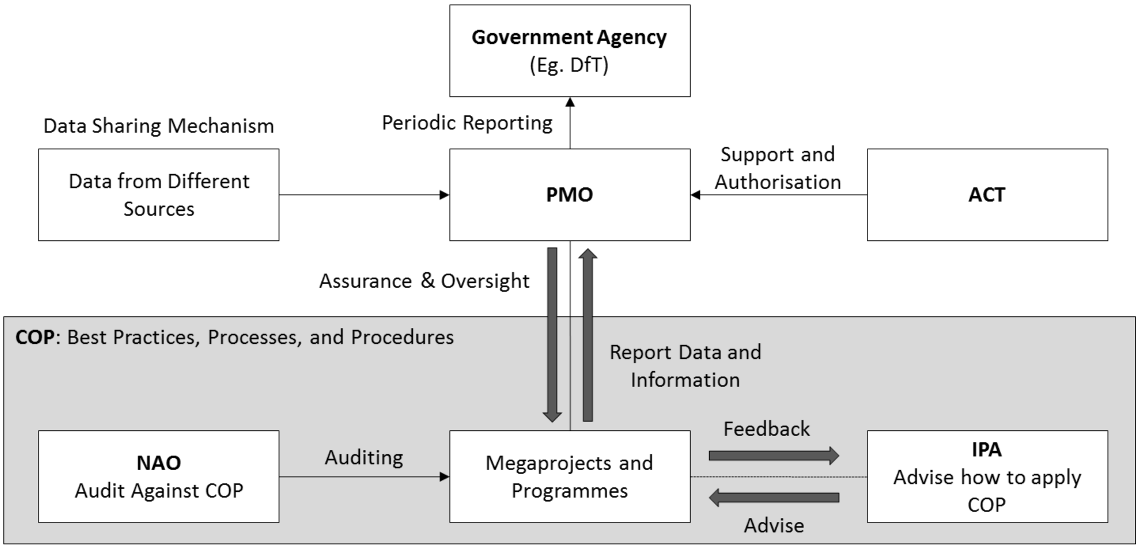

Figure A1.2 Governance Model of Megaprojects

Section 1.3 - COP

The development process of COP presented in Figure A1.3 is developed based on the opinion of Megaprojects experts.

Category	ID	Questions
COP	Q3.	• What are the practical challenges of developing this COP in the UK? • Do you think it is structured properly? • Do you recognise any missing elements with this process? • Do you recommend any modification that would improve it?

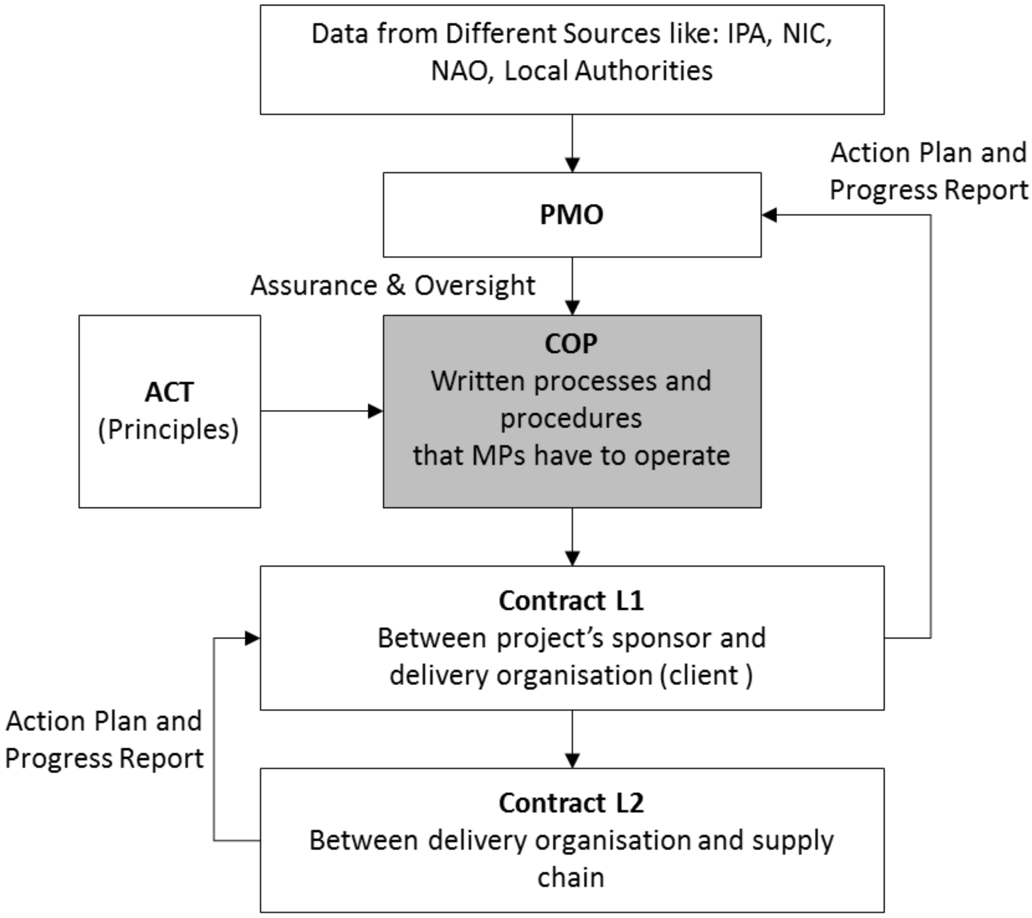

Figure A1.3 The Development Process of COP

Section 1.4 - NFC

The development process of NFC presented in Figure A1.4 is developed based on the opinion of Megaprojects experts.

Category	ID	Questions
NFC	Q4.	• What are the practical challenges of developing this NFC in the UK? • Do you think it is structured properly? • Do you recognise any missing elements with this NFC? • Do you recommend any modification that would improve it?

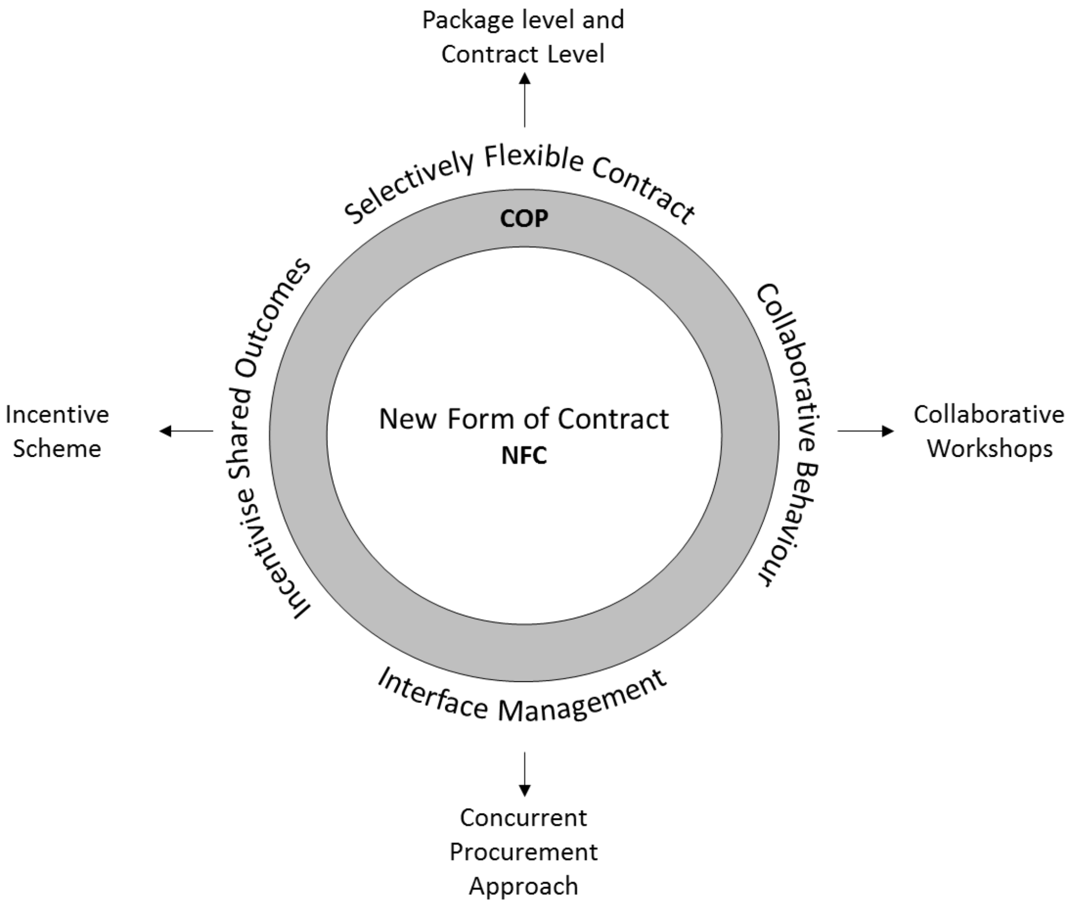

Figure A1.4 NFC Elements

Appendix N

Delphi Validation – Round 2

The first round of Delphi validation session showed that there were some comments and suggestions from Megaprojects experts panel on the four elements of the proposed approach (ACT, PMO, COP, and NFC). Accordingly, these valuable recommendations were considered, summarised, and reflected in the initial design of the proposed approach in order to improve it and make it practicable. As a result, the four elements (ACT, PMO, COP, and NFC) of the proposed approach of risk management have been revised and modified, as shown in Figure B1.1 to Figure B1.4 respectively. These modifications are highlighted by red while some others are deleted. The goal of this round is to share with you these modifications and find out whether you agree with these modifications or not in ordered to reach a high degree of consensus among the whole experts' panel members. In this regards, I would like to have a look at Sections 1.1 to 1.4 and prepare some answers to the questions in each section.

Section 1.1 - ACT

The legislative exemption mechanism presented in Figure B1.1 is revised and modified based on opinions of Megaprojects expert's panel gathered from the previous round.

Category	ID	Question
ACT	Q1.	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any modification that would improve it?

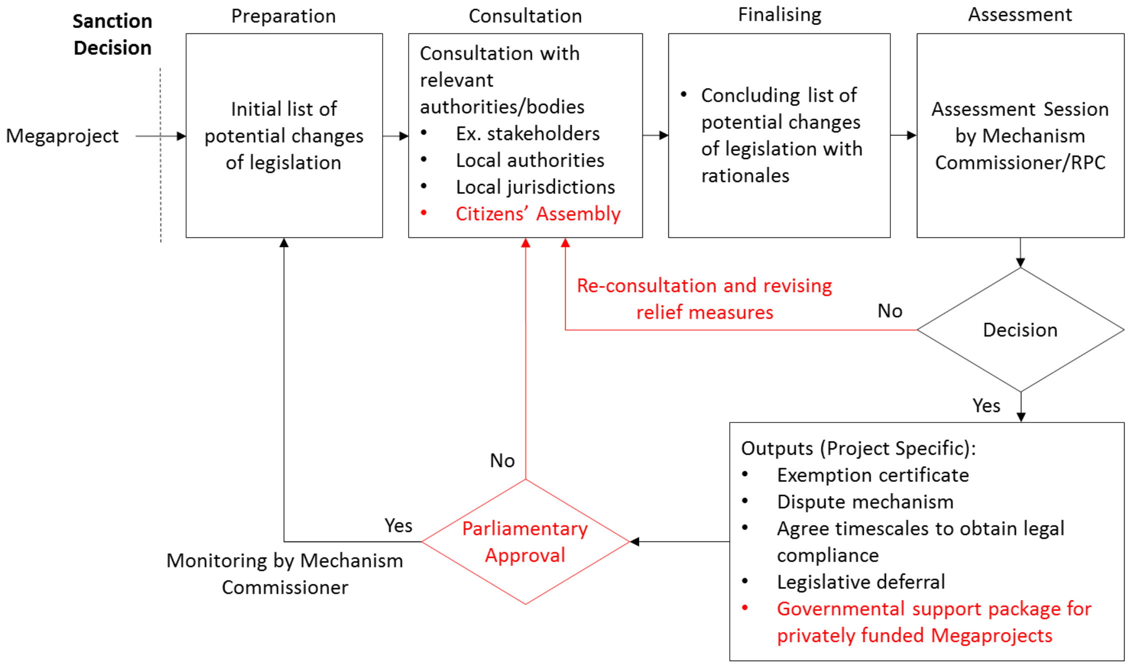

Figure B1.1 Legislative Changes Exemption Mechanism

Section 1.2 - PMO

The governance system presented in Figure B1.2 is revised and modified based on opinions of Megaprojects experts panel gathered from the previous round.

Category	ID	Question
PMO	Q2.	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any modification that would improve it?

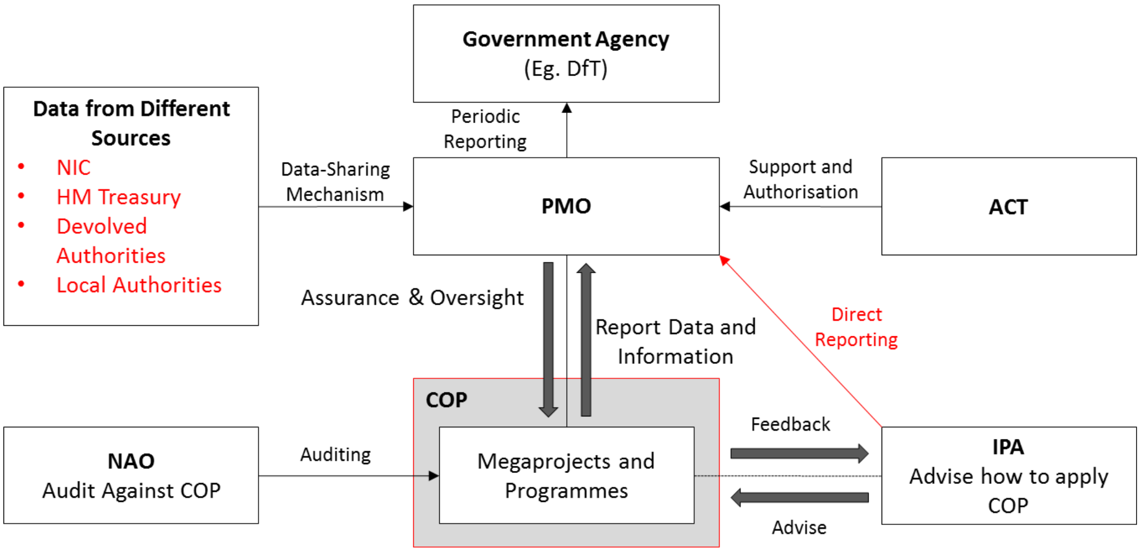

Figure B1.2 Governance Model of Megaprojects

Section 1.3 - COP

The development process of COP presented in Figure B1.3 is revised and modified based on opinions of Megaprojects expert's panel gathered from the previous round.

Category	ID	Questions
COP	Q3.	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any modification that would improve it?

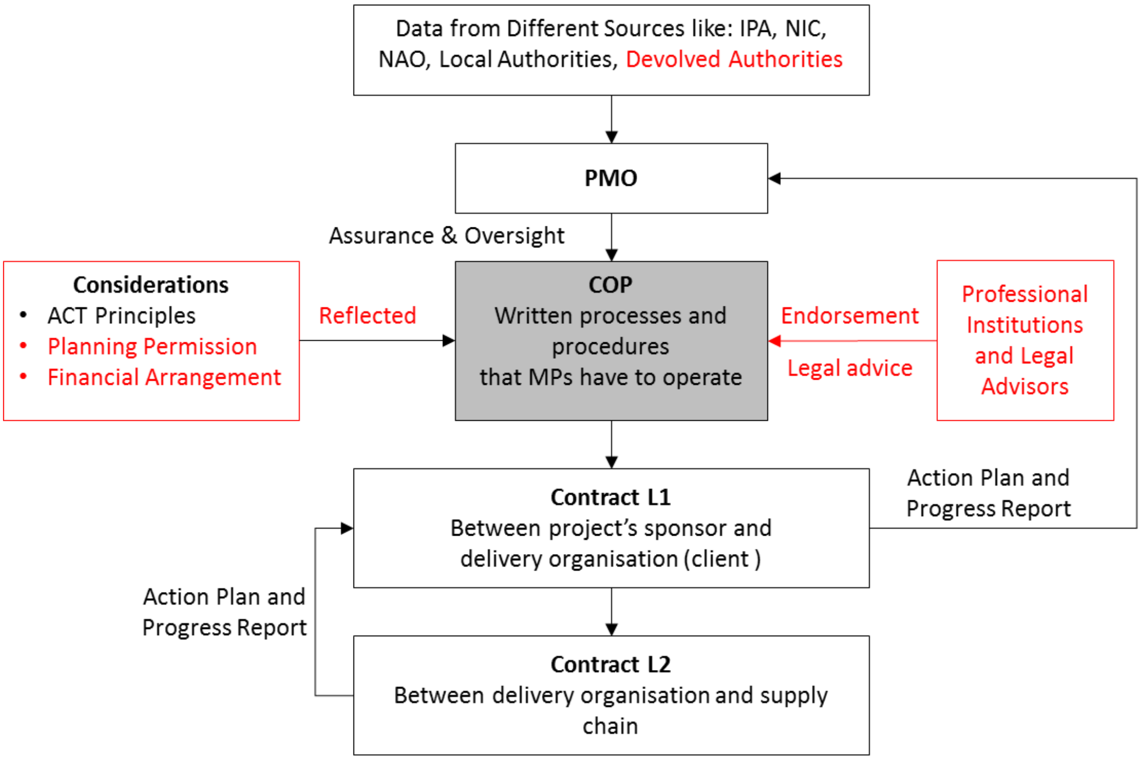

Figure B1.3 the Development Process of COP

Section 1.4 - NFC

The development process of NFC presented in Figure B1.4 is revised and modified based on opinions of Megaprojects expert's panel gathered from the previous round.

Category	ID	Questions
NFC	Q4.	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any modification that would improve it?

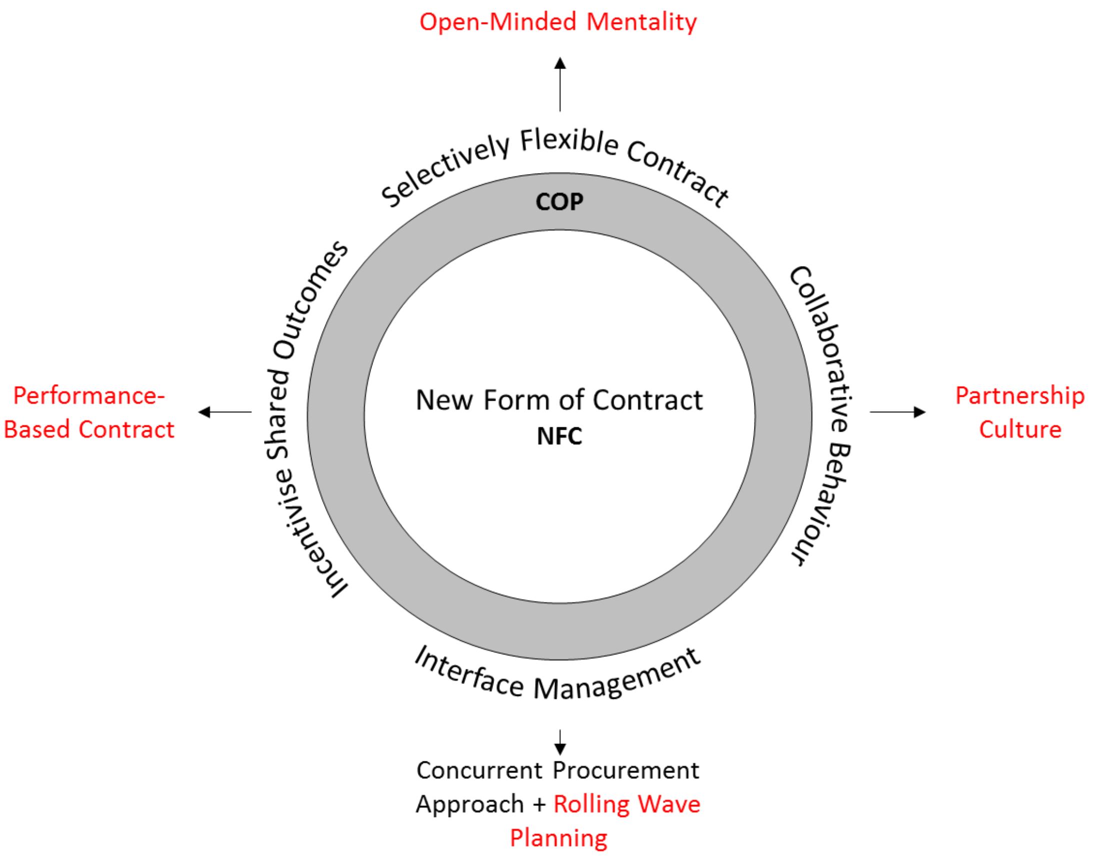

Figure B1.4 NFC Elements

Appendix O

Delphi Validation – Round 3

The second round of the Delphi validation session showed that there was a good agreement among the Megaprojects experts panel on the modified design of four elements of the proposed approach (ACT, PMO, COP, and NFC). It also shows that there were additional suggestions on minor issues that need to be considered. Accordingly, these suggestions (highlighted by red) were also considered, summarised, and reflected in the modified design of the proposed approach. As a result, the four elements (ACT, PMO, COP, and NFC) of the proposed approach of risk management have been revised again, as shown in Figure C1.1 to Figure C1.4, respectively. The goal of this round is to share with you these modifications and find out whether you agree with these modifications or not in ordered to reach a high degree of consensus among the whole experts' panel members. In this regards, I would like to have a look at Sections 1.1 to 1.4 and prepare some answers to the questions in each section.

Section 1.1 - ACT

The legislative exemption mechanism presented in Figure C1.1 is revised and modified based on opinions of Megaprojects experts panel gathered from the previous round.

Category	ID	Question
ACT	Q1.	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any further modification that would improve it?

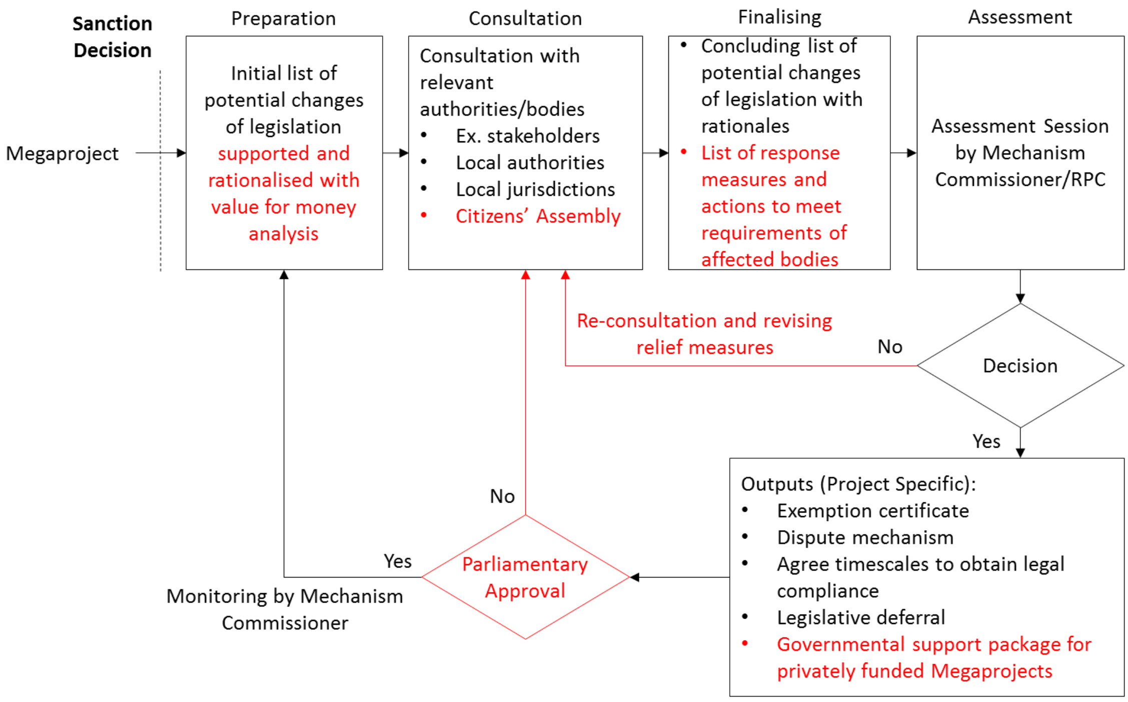

Figure C1.1 Legislative changes exemption mechanism

Section 1.2 - PMO

The governance system presented in Figure C1.2 is revised and modified based on opinions of Megaprojects experts panel gathered from the previous round.

Category	ID	Question
PMO	Q2.	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any further modification that would improve it?

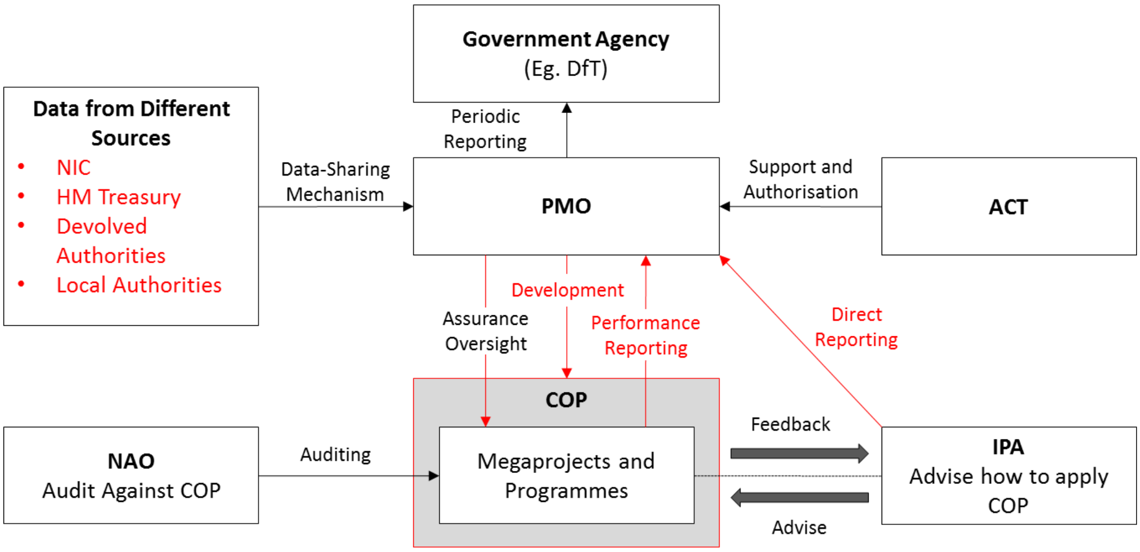

Figure C1.2 Governance Model of Megaprojects

Section 1.3 - COP

The development process of COP presented in Figure C1.3 is revised and modified based on opinions of Megaprojects experts panel gathered from the previous round.

Category	ID	Questions
COP	Q3.	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any further modification that would improve it?

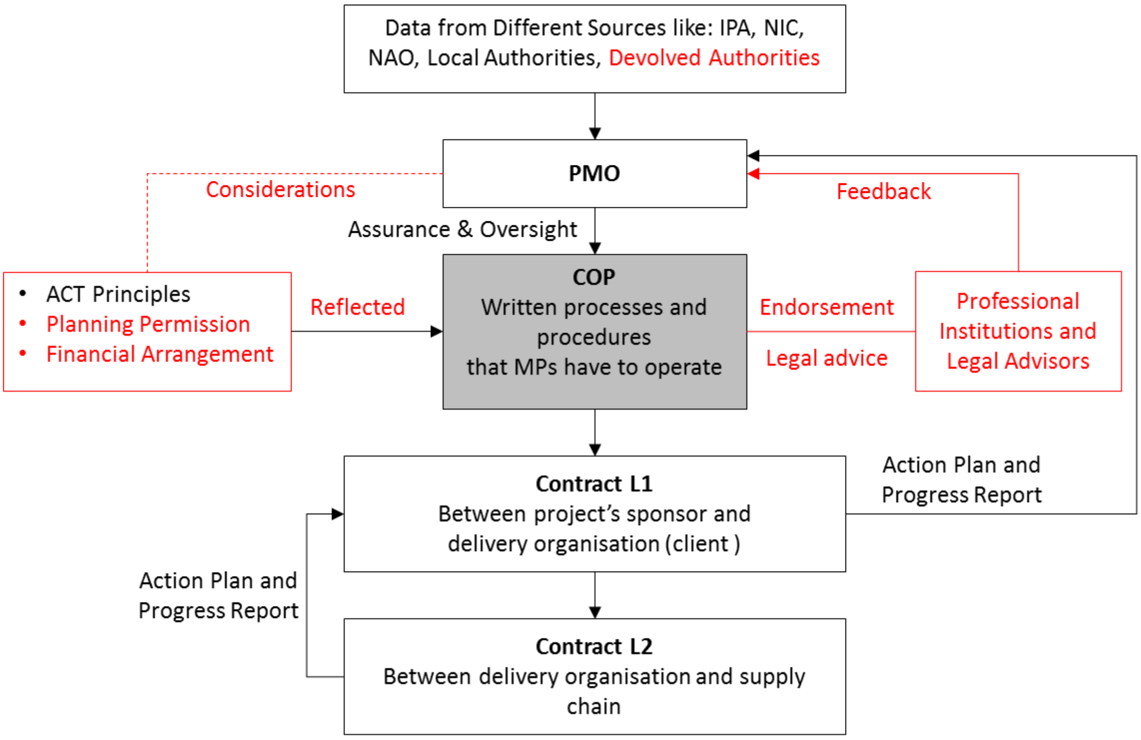

Figure C1.3 The Development Process of COP

Section 1.4 - NFC

The development process of NFC presented in Figure C1.4 is revised and modified based on opinions of Megaprojects experts panel gathered from the previous round.

Category	ID	Questions
NFC	Q4.	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any further modification that would improve it?

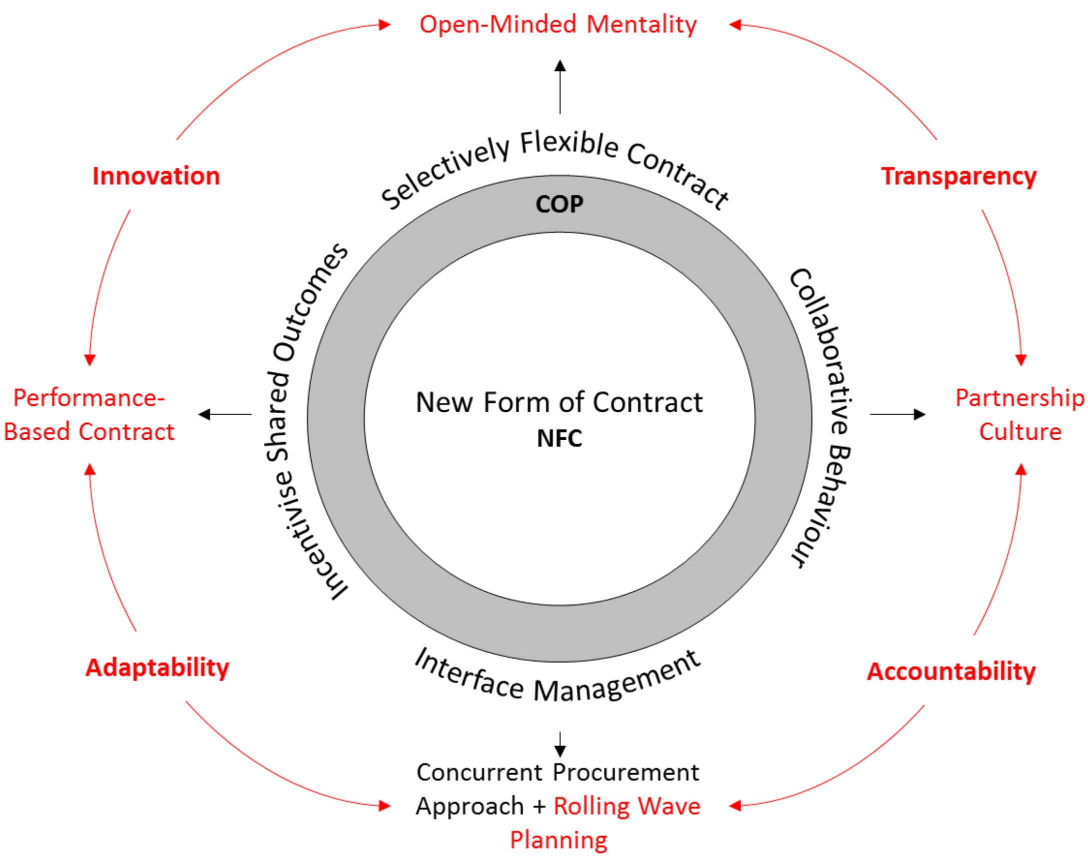

Figure C1.4 NFC Elements

Appendix P

Delphi Round 1 Questions and Transcriptions

Theme	No.	Question	Transcription
ACT	**Q1.**	• What are the practical challenges of enabling this ACT in the UK? • Do you think it is structured properly? • Do you recognise any missing element? • Do you recommend any modification that would improve it?	**First suggestion – including citizen assembly** • I think there is an argument for more rather than less for a democratic involvement at some stages in your legislative exemption framework mechanism. EP1 • What I suggest is you might need to include in your mechanism something like citizen assembly, which fashionably talking about major issues like Brexit, Climate change, and other things. EP3 • I like the concept, but I would presume there is an equal risk in the opposite direction, which is if you do that the project will be delayed anyway by the public affected from the project. EP4 • I can't see any missing element, as you've got a consultation box with the relevant authorities and bodies and I assume that in some way public are presented in one of these authorities. EP5 • I think you need to acknowledge the public role in your framework .. I think they should be allocated within where decisions are made. EP6 • Let me say what I think, there is a risk here which you may not be considered which is the non-violent direct actions against such Megaprojects, although that risk doesn't happen in Megaprojects in this country, however it has happened with some infrastructure projects in other countries …. so for example in 1990 The M3 motorway was disrupted why month by people sitting in front of. EP8 **Second suggestion – including parliamentary approval** • I'm not sure how your approach is going to be implemented in reality... I think the big challenge is how you can exempt Megaprojects from national laws and policies like those associated with global warming etc. … I suppose you can do this with Byelaws than national laws unless you have some parliament consent. EP1 • Even if you had this exemption certificate under the unwritten British constitutional as kind of emerge that doesn't allow a future Parliament could resend that … I am suggesting building into your process a legislative approval kind process to reduce the effect of UK constitutional risks. EP2

Theme	No.	Question	Transcription
			• The main problem that I see which is a UK problem, particularly in relation to your approach, which is constitutional issues, is the case that a phrase that goes no parliament can bind successor .. what I suggest is the output of this mechanism need to be subjected to parliament review in either direction. EP3 • It is difficult to operate this mechanism within the UK context simply because the parliament cannot approve since it will tide their hands … you need to get the approval from them to ensure inclusivity. EP7 **Third suggestion – enforce the consultation** • More consultation would be necessary after the decision is made .. it is not enough to change or revise the mitigation actions only. EP4 • As far as I'm concerned is the loop in your mechanism needs to be back again to the consultation phase rather than the finalising phase .. the reason why I am saying this is we are talking on Megaprojects that could affect public significantly. EP5 • From my perspective .. if an exemption request is not secured, the project would properly need to do further consultations with the local regulators and other agencies to address their concerns and provide sound alternatives. EP7 **Fourth suggestion – provide government support for privately funded Megaprojects** • I accept the principle, and I can see the point of isolate Megaprojects from externalities, and I agree with … but you need more considerations about what are the funding sources to the project, i.e. whether it is a government-funded project, privet funded project, or is it like a utility bill. EP2 • I think one of the challenges that your approach would face is the diversity of Megaprojects in terms of the planning permission and financial arrangements … your approach seems to be more suitable for public projects rather than private one … I suggest having a governmental support package for those privately funded. EP3
PMO	**Q2.**	• What are the practical challenges of developing this PMO in the UK? • Do you think it is structured properly?	**First suggestion – include input from devolved authorities:** • If the PMO create such COP, then it is a good thing to have a representative from devolved authorities and administrations on the PMO and will be a simple way to ensuring the PMO console them in creating a code of practice … I think something about bringing in having a formal role somewhere here from devolved administrations from Scotland and Wales and Northern Ireland if it exists and also and also from devolved authorities in England. EP2

Theme	No.	Question	Transcription
		• Do you recognise any missing elements with this system? • Do you recommend any modification that would improve it?	• I think what is missing in this PMO governance framework is the input from other bodies like where appropriate. EP8 **Second suggestion – direct feedback from the IPA to the PMO** • I'm of the opinion that the IPA has fewer teeth comparing with your new PMO origination .. but I think, you can't simply separate them … so it seems to me that the IPA should be part of the PMO by reporting the latter on Megaprojects progress. EP1 • Yes, I have no objection on this PMO governmental model … the only thing that comes to my mind is that why the IPA is isolated from the PMO .. so what I suggest is if you could integrate the IPA with your PMO then that could improve your framework. EP3 • From my viewpoint, I think you need feedback and advice from the IPA top to the PMO because the data can be biased from Megaprojects. EP4 • I think you need an angle between IPA and PMO directly in your diagram otherwise Megaprojects people can stop the PMO from to hear anything from the IPA … I think the IPA need to report directly to the PMO. EP7 **Third suggestion – the NAO needs to be outside the COP box** • I think although the NAO should not be a part of the PMO structure, but obviously, it should be cited .. so I would make it outside the grey box, i.e. outside the process of developing the code of practice. EP5 • I don't really like putting the NAO in the code of practice box .. simply because the NAO role is to provide independent auditing process … so I would take it out this box. EP8
COP	**Q3.**	• What are the practical challenges of developing this COP in the UK? • Do you think it is structured properly? • Do you recognise any missing elements with this process?	**First suggestion – provide an endorsement mechanism** • I wonder if there is a process whether people can complain if the code of practice or to provide some feedback on the content of such code of practice .. I think the endorsement from professional groups and legal advisors is likely to be beneficial for this process. EP1 • Although, the code of practice will differ from project to project the idea of re-invent it every time you come across a new project that will have to make a sense … however, you need an endorsement from professional critics and experts to refine it and reduce the risk of delivery. EP2

Theme	No.	Question	Transcription
		• Do you recommend any modification that would improve it?	• I really think you might need an endorsement here with your code development process... You want somebody to act as a kind of external consultant to make sure that your code of practice really reflects the cutting-edge practices and to fill gaps if any. EP5 **Second suggestion – consideration of the planning and financial arrangements** • I would say yes for the principle, your code of practice also need to have a full range of principles from different departments like the development of a high standard of health and safety .. otherwise, it will never work simply because each department has its unique requirements and standards that influence the project. EP3 • I think that sensible suggestion, the principles from different departments have to be feed into the code of practice because the lack of data is a major risk for data integration projects like Megaprojects … this needs to be considered. EP4 **Third suggestion – consideration for devolved authorities** • I think the principle of the idea of a code of practice overseen by project management organisation is a good one .. but you just need to make sure that this project management organisation to have the right experience and expertise from different bodies and organisations to develop and mandate such code. EP1 • If the PMO create such COP, then it is a good thing to have a representative from devolved authorities and administrations on the PMO and will be a simple way to ensuring the PMO console them in creating a code of practice … I think something about bringing in having a formal role somewhere here from devolved administrations from Scotland and Wales and Northern Ireland if it exists and also and also from devolved authorities in England. EP2 • It is not uncommon to have a structured contract between government-sponsored body and delivering body... but your point is to a grade of consistency and a grade of recognition of what is important to have in the contract level one additional year, so yes I absolutely agree with this. EP6
NFC	**Q4.**	• What are the practical challenges of developing this NFC in the UK? • Do you think it is structured properly?	**First suggestion – the need for open mined** • What we really need, which really difficult is a change of the mind-set, because what the contract does is reflect the mind-set of the owner and the owner advisors, which are normally lawyers and bankers .. what we tend to see was the owner tend to transfer all the risks to the contractor, which is a legitimate thing to do but logically it is not sensible. EP3

Theme	No.	Question	Transcription
		• Do you recognise any missing elements with this NFC? • Do you recommend any modification that would improve it?	• I like the idea of having all of these elements into one contract, but you might need to consider the fact that even with this selectively flexible approach, there is a tendency to put more restrictions and specifications that make the project less controllable .. so this mentality should be changed. EP5 • I think the world of project management has become separated from the reality of managing projects and the reality of legal positions in the contract .. so what we might need a realistic approach where people can be adaptive to changes. EP6 **Second suggestion - rolling-wave planning** • It is very difficult to produce a detailed schedule for very large projects over several years from the start to the end … what you really want is a rolling wave planning where you can plan your project periodically .. this parodic plan should be fully exhausted with details but not for the whole project. EP2 • I suppose what is really matter is the existing contractual arrangements need to be more agile to avoid and eliminate problems, and unforeseen risks resulted from system integrations .. something like that would properly work for your new form of contract. EP8 **Third suggestion - performance-based contract** • We don’t need very big documents of contract commitment with a lot of details, and I think what we really need is to move toward using performance-based contract … such an approach can only be successful if the client provides a clear and precise definition for his requirements and project outcomes. EP1 • In order to motivate the suppliers, I would suggest focussing more on the outcome-based contract schemes, where everyone in the project needs to be aware of and clear about the definition of the outcomes... It should be seen as either performance-based or prescriptive-based without focusing on details to be mandated with more flexibility across Megaprojects. EP2 • To improve the situation, I would suggest that major projects practitioners need to focus on the delivery performance than their narrow definition to the project because that would increase the level of complexity and add more restriction to the changing nature of Megaprojects. EP4 **Fourth suggestion - collaborative** • I think this is sensible to have a collaborative environment, which is already existed in our standards and codes of practice … however, what you might need to accommodate in your contract something like win-win scenario because there is an artificial relationship between the client and the contractors. EP4

Theme	No.	Question	Transcription
			• What is interesting about your approach is it advocate for more collaboration between the contracting parties, which I totally agree with … but I also recommend advocating for a strong partnership culture to prevent cultural conflicts so everybody can be responsive, especially with a large number of stakeholders in Megaprojects. EP7

Delphi Round 2 Questions and Transcriptions

Theme	No.	Question	Transcriptions
ACT	**Q1.**	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any modification that would improve it?	**Adding value for money statement in the preparation phase.** • I would suggest that the preparation phase should be heavily guided by value for money analysis, not just a list of legislations because it can play a critical role in the decision-making process of your model. EP1 **Make the finalising phase more comprehensive** • I think the statement "list of response actions" is unclear and need to be more comprehensive … I would add "to meet requirements of affected bodies". EP5
PMO	**Q2.**	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any modification that would improve it?	**Clarify the directions of the lines from the PMO down to the COP and Megaprojects.** • I think Megaprojects and programs need to provide and report PMO with their performance outputs as early as possible to allow POM measure their compliance with COP... so what I think you need to illustrate these lines more claret as the current one confuse the process. EP1
COP	**Q3.**	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why?	**Indicate the feedback line from IPA to the PMO** • I can see there is a missing line from the endorsements box to the PMO... these professional and legal advisors need to report their feedback to the PMO in order to address it and reflect it in the code of practice. EP5 • There is no indication of the endorsement and legal feedback in the diagram.EP8

Theme	No.	Question	Transcriptions
		• Do you recommend any modification that would improve it?	**Indicate the consideration line between PMO and considerations** • There is no indication of the PMO consideration to the planning permission root and financial arrangements of Megaprojects in the diagram ... I would add this line as long as it should be work like this. EP8
NFC	**Q4.**	• Do you agree with these modifications? If yes, would you like to adjust your initial feedback in the first round (if needed)? If no, could you explain why? • Do you recommend any modification that would improve it?	**Incorporate the innovation** • I agree with what you have said... I think we need to be flexible to respond to changes because in Megaprojects many things can be changed over time... this requires innovation in both technical and non-technical areas. EP4 **Incorporate the adaptability** • I think the contracting parties need to be adaptable... because many projects don't do this well... I think there is an expectation that you let the package to a supplier and the supplier manage it with other without enough adaptability. EP1 • From my perspective, I think these are good suggestions … the rolling wave system it is quite similar to system engineering approach... which is about defining your requirements then manage your delivery against these... so you need to ensure that the contract needs to be adaptive to changes, which I think it is a critical success factor in the contract. EP5 • I think these elements are correct and I endorse that... because I think these are things that always cause problems rather than the package that we are delivering. EP8 **Incorporate the accountability** • I think the collaborative behaviour is the key in the whole contract by taking into consideration the accountability because some stakeholders know how to playgroups off each other… so traditionally we can see less collaborative behaviour among the contracting parties. EP4 • I think in public sector procurements you need to emphases on the accountability because you are spending the public money... so I would add that in your framework. EP7

Theme	No.	Question	Transcriptions
			Incorporate the transparency • I am fully supportive of this new form of contract... however, collaboration means different things to different people... so I would suggest that you need to incorporate within you approach a **transparency mechanism** to ensure that there are no hidden agendas. EP1

The Response Rate of Megaprojects Experts' Panel in the Delphi Three Rounds

Round No	E1	E2	E3	E4	E5	E6	E7	E8	Response rate
Round 1	✓	✓	✓	✓	✓	✓	✓	✓	8/8
Round 2	✓	X	X	✓	✓	✓	X	✓	5/8
Round 3	✓	X	X	✓	✓	✓	X	X	4/8