International Journal of Project Management 41 (2023) 102502

Contents lists available at ScienceDirect

International Journal of Project Management

journal homepage: www.elsevier.com/locate/ijproman

Naturalistic decision making and decision drivers in the front end of complex projects

Ama Lawani [a,*], Rhona Flin [b], Racheal Folake Ojo-Adedokun [c], Peter Benton [d]

[a] Lecturer in Project Management and Leadership, Management, Work and Organisation Division, Stirling Management School, University of Stirling, FK9 4LA, United Kingdom
[b] Professor of Industrial Psychology, Aberdeen Business School Robert Gordon University, Garthdee, Aberdeen AB10 7QE, United Kingdom
[c] Lecturer in Management, Aberdeen Business School, Robert Gordon University, Garthdee Road, Aberdeen AB10 7QE, United Kingdom
[d] Director, Cephas Project Management Ltd, Aberdeen, Scotland, United Kingdom

ARTICLE INFO

Keywords:
Naturalistic decision making
Intuition
Front end of projects
Complex projects

ABSTRACT

Decision making plays a crucial role in the front end of projects which is a critical stage for maximising the performance of complex projects. Although it has been suggested that project managers rely more on analytical approaches to decision making as opposed to an intuitive mode, there is emerging evidence of project managers using intuitive decision processes. Yet, little is known about how this occurs during the front-end phase, with few attempts to study the underlying cognitive processes and what influences project decision making. This research gap is addressed by interviewing project managers experienced in front-end decision making ($n = 16$) of large-scale complex projects within the oil and gas industry. Adopting a naturalistic decision-making (NDM) methodology and using a form of cognitive task analysis, a thematic coding of their accounts of decision making during the front end of large complex projects identified key decision processes and influencing factors (drivers). Formal analytical processes (e.g., data-driven calculations, software rating tools) were favoured but, and in line with emerging findings, these experienced project managers also used intuitive decision-making processes, such as pattern recognition and feelings/associative memory. Decision drivers were grouped into 5 clusters - project external factors, project internal factors, social dimensions, individual differences, and time pressures. The findings suggest that project managers should be trained on how to recognise when intuitive decision making is occurring and how to use it while being aware of its strengths, weaknesses and influencing factors. A focus on building descriptive models of actual decision making in complex environments, for the training of project managers, by applying NDM methods will enhance the management of the front end of projects.

1. Introduction

Large-scale complex projects can be highly complicated, cost-intensive and of comparatively long duration, involving a network of multiple firms and sub-system suppliers, working collaboratively in project delivery (Chakkol, Selviaridis, & Finne, 2018; Davies & Mackenzie, 2014). At this level of project management, the early stage or front-end is critical for project success (Serrador & Turner, 2015, Davies & Mackenzie, 2014). The UK Government Infrastructure and Projects Authority emphasised the importance of this stage, which they call front-end loading, defining it as 'the implementation of robust planning, design and preparation for project execution in the early stages of a project's lifecycle to improve the potential for a successful project' (Smallwood, 2020 p1). The opening phase of large-scale complex projects (Flyvbjerg, 2013) has a high impact on project outcomes (Edkins et al., 2013; Shiferaw et al., 2012), as well as creating value (Zerjav et al., 2021; Artto et al., 2016).

The significance of the front-end of projects is due to the crucial, strategic decisions that are made during the early project definition stage (Chenger & Woiceshyn, 2021; Zerjav et al., 2021; Serugga et al., 2020). These allow for sighting of opportunities, idea creation and are the basis for subsequent project and portfolio success (Cravens, 2017; Heising, 2012). It is well recognized that project managers rely on analytical approaches to decision making (Al-Harbi, 2001; Yang & Lin, 2013; Hazır, 2015). For example, the cost-based analysis approach is commonly used in the front end of projects (Volden, 2019). While some

* Corresponding author.
E-mail address: al55@stir.ac.uk (A. Lawani).

https://doi.org/10.1016/j.ijproman.2023.102502
Received 4 June 2022; Received in revised form 23 July 2023; Accepted 4 August 2023
Available online 17 August 2023

studies have identified challenges associated with analytical decision making (such as absence of emotions and motives of project stakeholders and over dependency on availability of accurate information) (Parth, 2013), other studies have suggested that incorporating objective fact-based analysis with knowledge obtained from past experience impacts the decisions made (Huff & Prybutok, 2008). Despite the recognition that decisions made in the project's front end can significantly influence the project's outcome (Morris, 2011), studies on how actual decisions are made in the front end of projects are scant (Babaei et al., 2021; Newman et al., 2020). There is an emerging evidence of project managers using intuitive decision processes (Leybourne & Sadler-Smith, 2006, p 491; Musca et al., 2014), but little is known about how this occurs during the front-end phase, with few attempts to study the underlying cognitive processes.

In addition, there is a limited literature on what factors influence project decision making (Eweje et al., 2012; Stingl & Geraldi, 2017, 2021; Turner, 2020), especially at the front-end stage, although multiple studies have been conducted on the overall drivers of project success/-failure which vary depending on the type of project (Belassi & Tukel, 1996; Joslin & Muller, 2016; Jugdev & Muller, 2006). Project complexity influences time, cost and quality of a project and therefore impedes project objectives (Cicmil, Cooke-Davies, Crawford, & Richardson, 2017) and relates to project success or failure (Montequin et al., 2018). Arguably factors influencing overall project success/failure affect project managers' decision making as this activity is an intervening mechanism (Elbanna, 2015; Turner, 2020). Since decision making drivers have not been fully documented for the front-end stage of project management, these were also explored in the study.

Consequently, our investigation was designed to address two research questions (RQ):

(RQ1) How do experienced project managers make decisions during the front-end of complex projects?

(RQ2) What are the decision-making drivers in the front-end of complex projects?

This paper addresses the above research gaps by adopting a Naturalistic Decision Making method to explore decision-making processes (with emphasis on intuitive approaches) and potential decision drivers in the front-end management of complex projects. Oil and gas projects were used in our study because they are classified as large complex projects used to deliver strategic assets (Eweje, Turner & Müller, 2012). Research participants were experienced senior project managers who had played a key role in the front end of projects by virtue of their expertise to help explicate a viable and realisable project (Williams, Vo, Edkins, & Samset, 2019 pg. 19) and by generating and enhancing new project ideas (Salter et al., 2015).

The study contributes to the literature on management of a project's front end by explaining how experienced project managers make decisions at this crucial stage of projects and when they are likely to use intuitive modes of decision making. It leads to questions about the association between intuition and biases such as power bias (Flyvbjerg, 2021) and how project managers make decisions when interacting in their environment (Turner, 2020). Our findings indicate the need to broaden our understanding of decision making at the front end of projects by developing more detailed descriptive models of decision making for training project managers. The next section of this paper discusses the theoretical background that guided the study - the front end of projects, decision making and biases and the factors that influence decision making. The research methodology is described next, followed by the findings about how decisions are made by experienced project managers at the front end of projects and what drives them to use these approaches. In the final sections we discuss the study's limitations and contribution to project management theory and practice.

2. Theoretical and practical foundation

Decision making is one of the most valuable skills of a project manager, therefore its study is not new. The ability to make appropriate decisions during the front-end of projects reduces the likelihood of subsequent problems in project execution (McClory et al., 2017; Turner, 2014; Williams et al., 2012) and increases the probability of achieving project success (Williams et al., 2019; Wang & Gibson, 2010). However, research has identified a lack of ability to manage at this stage (Denicol et al., 2020; McClory et al., 2017).

Martinsuo, Vuorinen, and Killen (2019) pointed out that decision making at the front-end stage can be particularly challenging as this can require not only the framing of values, but also subjective long-term predictions based on uncertain information. Similarly, Haji-Kazemi et al. (2013) acknowledged that difficulties can be caused because several early warning signs (especially those related to technical issues) are not easily detected at this stage. Babaei et al. (2021) identified several factors (e.g., too little attention to qualitative data, bias) that contribute to problems in decision making at this front-end stage. Likewise, Eriksson and Kadefors (2017) case study revealed that cognitive heuristics may have a strong effect on complex non-standard projects. The project management literature has long argued that relying exclusively on either analytical or intuitive decision making will produce poor project outcomes (Cohen, 2005).

There has been increasing interest in the role of intuition in managerial decision making (Burke & Miller, 1999; Sadler-Smith & Shefy, 2004; Dane & Pratt, 2007) including studies with project managers. Leybourne and Sadler-Smith (2006, p 491) found that not only did project managers report using intuition (which they described as 'those affectively charged, non-conscious cognitively based judgments which we refer to as intuition, hunch or gut feel') but that it was positively linked with improvisation. With a similar questionnaire method, Elbanna (2015) reported that the level of self-reported intuition in project managers was linked to team reflexivity (the extent to which project teams reflect upon and modify their functioning). The application of 'sensemaking' to 'reframe' projects (Musca et al., 2014) involves intuition, as Luoma and Martela (2021) have demonstrated for strategic decisions.

Calls for more attention to the intuitive aspects of project managers' decision making have been made. Stingl and Geraldi (2017, 2021) recommended a more naturalistic approach to studying 'decision making in the wild', arguing that a focus on simple fast heuristics and other intuitive methods in project management is overdue. "While managers silently accept 'gut feeling' and 'intuition' as part of their decision making, organisations are more likely to accept arguments based on procedural rationality. The consequence is that intuitive approaches such as 'gut feeling' remains hidden or treated as a magic sixth sense that cannot be touched, discussed, or validated (Stingl & Gerald, 2021, p9). Likewise, Turner (2022) notes how little psychological research has been conducted in project management in the last 40 years, with recent studies of emotional intelligence (which has an intuitive component) being one exception. The limited research on decision making in the front-end stage of projects suggests that if these intuitive processes are being adopted by project managers, then they are indeed, fairly well hidden. Although, there is increasing awareness on project decision making from a behavioural viewpoint, understanding how project managers actually make decisions at the front end of projects and factors that influence the decision making process are under researched. Alimadadi (2022) advises that adopting a pragmatic perspective on the experience of project practitioners would improve our understanding of the challenges associated with the front end of projects.

The current study is a practice-based investigation (e.g., Geraldi & Söderlund, 2018; Blomquist et al., 2010; Cicmil, 2006) which aims to understand the cognitive processes underlying project managers' decision-making at the front end of complex projects as well as the influence on actors when making decisions (Stingl & Geraldi, 2017; Mullaly, 2014). We adopted a naturalistic decision-making approach (Lipshitz et al., 2001) to explore decision methods and related influences (decision drivers). Our particular interest is on the role of intuitive

decision processes by project managers when making decisions at the front end of projects. If these do feature, along with the conventional analytical approaches, then project managers need to have a better understanding of how and when in decision making, intuitive processes can usefully be applied in complex projects. Moreover, if this study adds to the limited evidence which indicates that experienced project managers are using intuitive modes, this strengthens the case for including advice on these cognitive processes in project managers' decision training.

2.1. Front end of projects

An early description of the front end of projects identified three major steps of the phase – idea generation, preliminary assessment and concept definition (Cooper & Kleinsehmidt, 1995). Smith and Reinertsen (1998) devised the term 'Fuzzy Front End' to describe the early stages of a new product development comprising the period when the idea was conceived (and project objectives are vague) to its approval for development or termination (Murphy & Kumar, 1997). The term front end of projects is synonymous to 'front end loading' commonly used in the oil and gas, industrial and extractive sectors industry (Williams et al., 2019), and Saputelli et al. (2013) define this term to mean a project pre-planning process used to develop a detailed definition of the scope of a capital project to increase the probability of project success in terms of cost, schedule and operability. Another definition of front end of projects is in relation to 'strategic project shaping' which involves a range of activities; from creating the business case to managing the trade-offs between project requirements to determining the budget, schedule and quality and designing the project strategy used to gain project approval (Edkins et al., 2013). Smyth et al. (2018) provides a concise definition by stating that the front end is a stage when value propositions are formulated, is rich in interactions, especially for large complex mega projects. Although a number of slightly different representations of project front end exist, they all require some sort of strategic planning input, idea generation/screening or definition, a business analysis and project planning (Nobelius & Trygg, 2002). We considered the front end of a project as the stage when the project exists conceptually before it is operationalised (see Fig. 1, Volden & Samset, 2017, pg. 94). This stage comprises all activities from when the idea is conceived until a final implementation decision is made. In the conceptual phase, opportunities are assessed, and the project strategy is determined as well as its objectives. In the pre study and pre project phase, various project alternatives are analysed, and the preferred option selected. Uncertainty is reduced as more information is collected via available data, option appraisal and front-end engineering (Nava & Rivolta, 2013).

Despite the recognition of value being identified and created during the front-end of projects (Zerjav et al., 2021), these front end activities are filled with issues emanating from several aspects (e.g., skills and competences (Williams & Samset, 2010), conflicting goals and objectives between stakeholders (Klakegg, 2009), lack of information for decision making (Andersen et al., 2016) and unclear decision making process (Welde & Odeck, 2017; Samset & Volden, 2016)). Poor front-end management has also been regarded as one primary reason for cost overruns in addition to procurement, human resources issues, organisation, project processes and control (CII, 1987). A flawed front-end process with the best execution technologies and techniques would not derive as much value from a well-defined project during the front-end stage even if the execution were not seamless (Denney, 2006). Therefore, poor decisions made by project managers and executives during the front-end phase are, more often than not, irreversible, with the potential of extensively reducing value.

2.2. Modes of decision making and decision biases

Naturalistic Decision Making (NDM) is the way people use their experience to make decisions in field settings (Zsambok & Klein, 2014 pg4). NDM researchers have found that experienced decision makers in work settings are more reliant, than previously appreciated, on the faster, intuitive cognitive processes. These are built on their ability to recognise familiar features in new situations and their stored memories of the relationship between decisions and outcomes in previous similar instances. Klein called these fast processes 'recognition-primed' decision making and modelled the inherent components, such as familiarity judgements and mental simulation of how an identified course of action might unfold. This faster mode can also be called 'intuitive' decision making, a term which we have adopted in this study as it is already used in the project management literature (Elbanna, 2015; Leybourne & Sadler-Smith, 2006).

The intuitive mode typically encompasses rapid recognition of cues and patterns from stored memories, more reliance on heuristics, on affect and in some cases, little conscious awareness of the cognitive process of reaching the decision (Calabretta et al., 2017). These processes bring to mind judgements or candidate responses accompanied by a feeling of confidence or rightness in that judgement (Evans, 2019). Holistic associations involve matching environmental stimuli with non-conscious patterns or features stored in long term memory (Dane & Pratt, 2007). This intuitive mode is a characteristic of experienced practitioners rather than novices who lack the depth of stored knowledge. The affective element to intuitive judgement is reflected in labels such as 'gut feel' and 'gut instinct' (Hayashi, 2001; Dane & Pratt, 2007). Judgements that are affectedly charged suggest a presence of feelings and may indicate heuristic processes are operational (Stingl & Geraldi, 2021). Heuristics are mental shortcuts ('rules of thumb') which are generally useful but can lead to biases (Tversky & Kahneman, 2004). The risk of confirmation, optimism and other cognitive biases is higher with the intuitive mode of thinking (Kahneman, 2011). These biases are 'systematic and common tendencies, inclinations, or dispositions that skew or distort decision making processes in ways that may make their outcomes inaccurate or suboptimal' (Korteling et al., 2021, p1). It has been argued that irrational decision-making behaviour is rooted in the decision maker's bounded rationality (Simon, 1992) and emotion-laden cognitive biases, which can lead to errors (Kahneman, 2011). Whilst these biases also affect analytical decision making, they are typically associated with the faster, intuitive mode of thinking. They arise from the normal tendency to be economical with cognitive resources and to rely on mental short-cuts and heuristics, such as choosing a familiar option (Croskerry, 2013). Flyvbjerg (2021) pointed out that there are more than 200 types of bias and lists the top ten that affect project management (e.g., strategic misrepresentation, uniqueness, hindsight). The NDM researchers accept that bias can lead to error but compared to traditional decision researchers, they (e.g., Klein, 2022) are more positive about the value of heuristics which are widely employed and can

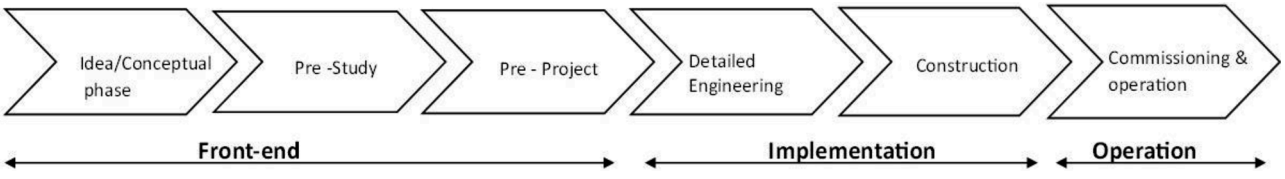

Fig. 1. Front end of projects Volden and Samset (2017).

play a key role in experienced project managers' decision processes (Eriksson & Kadefors, 2017).

In contrast, an analytical (sometimes called rational, e.g., Calabretta et al., 2017) approach to decision making is slower and much more cognitively demanding as it involves reflective reasoning (Evans, 2019). For a decision choice, it requires conscious attention to be focused on the generation and systematic comparison of options, following the compilation of data on key attributes of each option (Klein, 1993). While this method enables a rigorous review of the relevant features of alternative courses of action, it needs a significant amount of information, is very time consuming and usually requires paper and pencil or some other method of visual representation. There are many formal methods for reaching decisions in this way (e.g., subjective expected utility, multi-attribute modelling, Bayesian calculations) (see Shafiee et al., 2019). These analytical models are well known in business organisations and the associated calculation techniques (with software packages) are often the basis of managerial decision training.

While these two cognitive systems may function in a complementary fashion during decision making, the specific nature of the dual-process mechanism remains under debate (Hodgkinson & Sadler-Smith, 2018; Evans, 2019). Appropriate switching between these two modes of thinking during task execution is a hallmark of expertise and, as has been found for surgeons, is likely to depend on knowledge, time pressure and task characteristics (Moulton et al., 2010).

2.3. Factors influencing decision making in the front end of projects

As is common with managerial decision making (Bazerman & Moore, 2017; Roberts et al., 2021), there will be multiple factors that affect project managers' judgements, for example, information feed (Eweje et al., 2012). Other factors would include those external to the organization (e.g., regulation or market forces), internal factors (e.g., organizational culture or financial pressures) and factors relating to psychological characteristics of the project managers, such as risk propensity. Although the literature directly referring to factors that influence project decision-making is limited (Stingl & Geraldi, 2017, 2021; Turner, 2020), it does suggest that project success/failure factors are also drivers of decision making as discussed below;

The operational success factors (e.g., meeting time and financial performance targets) were distinguished from the strategic success factors (e.g., customers' need and future market success) by Shenhar et al. (2001) and Serrador and Turner (2015). In these studies, success dimensions contingent on broader elements of the project and outside the project execution stage were examined, such as the client's network of infrastructure and financial standing of the business, which arguably had a bearing on the decision making. A study of large infrastructure projects (Mišić & Radujković, 2015) identified a stable business cashflow and procedures for legal consents as success factors. It further concluded that an unstable and delayed decision-making process by both the client and the project delivery organisation, significantly influence a successful project delivery, suggesting a link between decision making and project success. Human behaviour drives project success, and it influences decision making, especially project managers' experience, political and strategic behaviours (Stingl & Geraldi, 2017). There is good evidence that psychological factors such as risk aversion in project managers (Kwak & LaPlant, 2005) play a key role. Shore (2008) considered how the decision outcome of a project relates to the influence of cultural, leadership and behavioural factors. He identified cognitive bias (e.g., groupthink, illusion of control, overconfidence, and selective perception) as key factors. Likewise, the seminal work by Flyvbjerg (2011, 2017) discusses optimism bias and strategic misinterpretation as influencers of complex project failures: Clients, project managers and planners deliberately underestimating costs and overestimating benefits in order to make the project seem more essential for a strategic purpose. While project professionals may attempt to eliminate bias and errors through scientific analysis, critical evaluations and peer review (Flyvbjerg 2009, 2017), biases and opportunistic behaviors need to be considered within the project context for a better insight into the underlying motives (Lefley, 2006; Winch, 2013). Competency development of project managers and stakeholder alignment (Crawford, 2005) are also influential on project performance. Stakeholder management was found to have the highest influence on mega project outcome by Mišić and Radujković (2015). Montequin et al. (2018) identified behavioural factors influencing complex projects and grouped them into 5 clusters – project, organisational, project manager, team members, and external. The project manager and team member factors (e.g., their skills, competence and commitment) scored highly as did the project and organisation factors (e.g., inaccurate or incomplete requirements, poorly defined specification).

Decision making drivers for the front-end stage of project management have not been directly investigated. Therefore, we followed Stingl and Geraldi's (2021) recommendation and in order to examine the drivers, we focused on real life matters studied in a 'rich decision' specific context. Our study advances understanding of decision-making in project management more generally by adopting a naturalistic lens to examine the decision processes used by experienced project managers.

3. Methodology

Psychologists in the field of naturalistic decision making have studied experienced decision makers in work environments for the last thirty years (Klein, 1993; Lipshitz et al., 2001). Their descriptive approach, which contrasts with the dominant normative orientation in the decision sciences, has been advocated for the study of project managers' decisions (e.g., Stingl & Geraldi, 2021; Turner, 2020) and is the perspective taken for this study. The research questions required that information be sought based on practitioners' decision-related experiences in the front-end stage of oil and gas industry projects. We used projects in this sector because they are characterised as large complex projects used to deliver strategic value (Eweje, Turner & Müller 2012).

An interpretivist epistemology was adopted using a predominantly deductive approach research design (Byrne, 2022) to explore how decisions were being made and the driving factors. However, conducting an exclusive deductive analysis is arguably not possible because of the value in understanding context-based meaning and relationships between information (Byrne, 2022). Therefore, an inductive approach was latent particularly for the second research question.

The target population was experienced project managers with more of a leadership role rather than traditional roles of project delivery (Eweje et al., 2012) which involve low levels of management with a focus on project efficiency described by Serrador and Turner (2015). The participants were managing or had managed large scale complex projects in the oil and gas industry and were either in charge of the front end or an extensive part of it. A semi-structured interview format was adopted, using a cognitive task analysis approach (Crandall et al., 2006; Clark et al., 2008) which helps to capture information about the knowledge and thought processes used by experienced practitioners to perform complex tasks. This 'more nuanced' type of interview method was recommended by Stingl and Gerardi (2021) for examining managerial decision making. Cognitive processes are difficult to study, and self-report based on recollected events has limitations for this purpose. Nevertheless, cognitive task analysis does offer a focused approach for extracting and analysing experts' accounts by using established markers (e.g., of particular decision-making methods).

3.1. Participants

Experienced project managers from the oil and gas industry were recruited between February and April 2021 by the fourth author (the project advisor acting on behalf of the funding body - Engineering and Construction Industry Training Board) who distributed information about the project through the Association for Project Management local

branch. Those managers who volunteered to participate in the study were sent an explanatory letter by the first author and the consent form. The initial target sample was 20 project managers which was deemed an appropriate size based on similar studies (Zerjav et al., 2021; Loosemore & Cheung, 2015). However, recruiting participants proved challenging due to the Covid 19 pandemic and consequent changes to working arrangements impacting project managers' availability. Therefore, snowball sampling (Alderman et al., 2005) was also employed. As the data reached saturation (Guest et al., 2006) around the 14th interviewee (i.e., little new material was emerging), it was decided to complete the interviews with the 16th participant and this sample size was approved by the sponsor. The 16 participants (14 males; 2 females) were senior project managers, with a total average of $\geq$ 13 years of senior project management experience. Most had worked as project managers for several companies in this industry. They were all UK-based, working on projects in the UK offshore region. They had various titles, such as development manager, project management consultant and project owner.

The initial recruitment criterion was ten years as senior project managers, but we included three participants who had 4 or 5 years at this position because of their level of participation in decision making at the front end of projects. Out of the 16 participants recruited, four were project owners tasked with making decisions during the front-end phase. A further nine were tier 1 contractors, who, in the North Sea oil and gas context, are usually given a high degree of decision-making authority at the front-end phase, especially in technical decisions, but who may also operate the asset on behalf of the owner. The other three were current project consultants for Tier 1 contractors, who, participated in the decisions being made and could comment on the factors that influenced them. These consultants had been involved in front end decision making in earlier positions. Details are shown in Table 1.

Table 1
Description of participants.

Interviewee Code Number	Years Senior Project Management Experience	Type of organisation	Comment
1	15	Oil & gas operator (Project owner)	Tasked with decision making role/Decision maker
2	10	Tier 1 contractor	High degree of decision-making authority at FEL
3	15	Tier 1 contractor	High degree of decision-making authority at FEL
4	4	Tier 1 contractor	High degree of decision-making authority at FEL
5	c.20	Project Consultancy	Participated in FEL decision making at high level for multiple projects
6	>10	Project Consultancy	Participated in FEL decision making at high level for multiple projects
7	10	Oil & gas operator (Project owner)	Tasked with decision making role/Decision maker
8	15–20	Tier 1 contractor	High degree of decision-making authority at FEL
9	5	Tier 1 contractor	High degree of decision-making authority at FEL
10	15	Tier 1 contractor	High degree of decision-making authority at FEL
11	25	Tier 1 contractor	High degree of decision-making authority at FEL
12	25	Oil & gas operator (Project owner)	Tasked with decision making role/Decision maker
13	10–12	Oil & gas operator (Project owner)	Tasked with decision making role/Decision maker
14	4	Project Consultancy	Participated in FEL decision making at high level for multiple projects
15	21	Tier 1 contractor	High degree of decision-making authority at FEL
16	12	Tier 1 contractor	High degree of decision-making authority at FEL

3.2. Interview schedule

The semi-structured interview schedule contained 14 questions, as follows: Part A consisted of demographic questions. Part B focused on the interviewee's experience of the front-end stage. (The term Front End Loading was used in the schedule as this is the common term in the oil and gas industry for this stage). Part C asked questions to probe the interviewee's practice of decision making in the front-end stage such as procedures for selecting project options and making decisions when faced with external risks during the front-end stage. In Part D, a version of the Critical Decision Method, a form of Cognitive Task Analysis (Crandall et al., 2006; Gore et al., 2018) was initially applied by asking participants to think of a particularly memorable and challenging decision that they had to make during the front-end stage of a project. They were then asked to describe the situation in which they had to make the decision and a series of questions probed their thought processes in reaching it. This technique is typically used with interviewees who make on-task, operational decisions, such as pilots (Bearman et al., 2009) or surgeons (Pauley et al., 2011). In these cases, the focus is on single decisions taken in a dynamic situation, characterized by significant time pressure. The decisions taken by the interviewees covered a whole range of situations ranging from technical recommendations (e.g., choice of design basis depending on temperature of input gas, which if incorrect, would involve at best costly rework and delay and at worst, would compromise offshore installation safety, (interviewee number 2) to taking a decision on the feasibility of an entire hydrocarbon development, putting at risk the investment of many hundreds of millions of dollars (interviewee 12)).

It transpired that this method of concentrating on a single decision was less suitable for the project managers as their front-end decisions tended to involve teams considering multiple inputs from different specialists and time periods (days or weeks rather than minutes or hours) for evaluation of sequential decisions. Where a more individual decision relating to a particular project was mentioned, the interviewee was asked questions relating to the decision-making process and influencing factors for that example. In other cases, more general questions on the participant's experiences during a range of decision situations (e.g., relating to identification and selection of options) were posed, exploring further responses in part C. Following a funnelling technique (Kvale & Brinkman, 2008), the general questions on decision making processes were asked before any specific questions which explicitly mentioned 'gut feel' or 'intuition' or 'pattern recognition'. Where participants had used this type of phrase spontaneously early in their responses, then this would be explored further during part D. The full interview schedule can be seen in Appendix 1. At the end of the decision method questions, participants were asked for details of any formal training they had received on how to make decisions for project management.

The length of each interview ranged from 60 to 90 mins (average 75mins). They were conducted by two or three of the academic members

of the research team via Zoom or Ms Teams video conferencing tools, recorded (with permission granted for all participants) and transcribed.

3.3. Data analysis

The transcribed responses were imported into NVivo (version 12) software which facilitates thematic analysis, through sorting, organizing and managing qualitative data (Clarke & Braun, 2017). Participants were anonymized by allocating a letter and number (P01, P02 etc.) to each interview file.

A thematic content analysis was used to identify the markers of analytical and intuitive decision processes modes through an iterative process involving two academic authors. The third academic author reviewed the extracted material to reach a consensus. All statements relating to decision processes were identified and then, with reference to the literature on decision making (see Sections 2.2) these were coded using a method similar to that of Calabretta et al. (2017). For intuitive processes, we classified respondents' decisions as intuitive when their statements included indicative words such as intuition, gut feel, automatic, holistic processing, pattern matching, rapidly, recognition of preferred/ discarded options. Statements relating to different types of biases (e.g., confirmation) and mental heuristics were also allocated to this category. For the analytical category, identifying statements included terms such as option comparison, systematic review, option ranking and rating methods, decision support software. Having allocated extracted material to these two main categories, it was further subdivided into the principal subcategories shown in Table 2.

The influencing factors (decision drivers) were identified using a predominantly thematic analysis with reference to the literature on decision drivers/project outcome drivers, (Section 2.3). A subtle inferential method was also applied alongside to understand context-based meanings (Byrne, 2022). The number of respondents mentioning each theme was noted as this can be a signal of relative importance, although we were aware of the limitations of this approach (Elliott, 2018).

4. Results

The first research question was to examine what types of cognitive processes are involved when experienced project managers make decisions in the front-end phase of projects. Types of decisions that were described in the interviews related to complex projects such as planning an exploration campaign, selecting a production method for a new oil and gas field, technology options for major retrofit. The types of projects that were being discussed, in relation to decision making processes, were mainly CapEx greenfield, offshore oil and gas developments (i.e., for a new field, how it should be developed in terms of the methods and architecture; the layout of miles of pipelines, where the oil and gas was to be exported to; materials to be employed, etc.) These tended to be very expensive (up to a billion dollars) and the project planning stages could be 18 months to two years or longer. In some cases, brownfield sites were discussed with new developments being based on or tied back to existing structures and these were also complex, with any risk to ongoing production potentially costing millions of dollars. Some examples were given of smaller OpEx offshore projects, such as methods of extending field life or retrofitting critical equipment on production facilities, which again could be costing millions of dollars.

The results of the analysis of the interviews to determine decision making modes is presented first, followed by the findings of the second research question, i.e., the analysis relating to the influencing factors (decision drivers). It was beyond the scope of this investigation to link the drivers to decision modes.

4.1. How experienced project managers make decisions during the front-end of project management

The two main decision-making modes were categorised as Intuitive and Analytical, with related characteristics shown in Table 2 and explained in the following sections, illustrated by selected quotes from respondents. As explained in the introduction, it was already well established that analytical decision processes were employed by project managers, and as shown in Table 2, this was confirmed. The content analysis also indicated that project managers do appear to use some intuitive-type cognitive processes and it was also evident that there was a degree of interplay between intuition and analytical approaches at certain times during decision making at the front-end stage.

Table 2
The result of the content analysis on decision making modes (numbers indicate how many respondents mentioned the characteristic).

Mode	Related Characteristics	Description
Intuitive decision making	Pattern recognition based on experience (14) Gut feel/Sentiments (12) Personal bias (10) Confirmation bias (6)	Process of sense-making involving thinking fast based on recognition of a pattern from previous experiences. (Lipshitz et al., 2001). Feelings/associative memory based on emotions, vivid imagery and associative memory (Dane & Pratt, 2007). A rapid preferential judgement for one option, a particular weighting score or solution for a problem due to some kind of bias/ heuristic (Kahneman, 2011). Seeking out and assigning more weight to evidence that supports a preliminary choice and ignoring or assigning less weight to evidence that could disconfirm it (Croskerry, 2013).
	Holistic processing or view (4) Optimism bias (2)	Ability to see the broader or big picture and focuses on looking at things as a whole (Gore & Sadler-Smith, 2011) Tendency to overestimate the likelihood of decision resulting in positive outcomes and underestimate the likelihood of negative outcomes. (Flyvberg, 2017)
Analytical decision making	The use of analytical/ software tools (12) Data-driven methods (10)	Using formal decision analysis tools (typically computer-based) to make calculations and compare options (Shafiee et al., 2019). Data driven techniques backed up by experience, collecting information from multiple sources to reach and/or back up a decision (Calabretta et al., 2017).
	Optimising (4)	A decision-making strategy that aims for the best solution which requires having full information on each option and the time to engage in an extensive consideration of data (Klein, 1993).
Interplay	Interplay between analytical and intuitive decision-making (10)	Co-occurrence of the subjective intuitive mode and the data-driven analytical approach to decision making (Leybourne & Sadler-Smith, 2006, Alimadadi, 2022).

4.1.1. Intuitive decision making

As explained above, intuitive decision making is a fast-cognitive process, which relies on holistic processing, matching stored patterns in memory and rapid judgements based on familiarity, with sensitivity to emotional components. While this mode of decision making has undoubted advantages, it may be particularly prone to cognitive bias. The

main characteristics of intuitive decision making identified from the interview transcripts were the three aspects labelled bias, pattern matching/ holistic processing and gut feel.

Several types of cognitive bias were identified, and these are well known in project management (e.g., Flyvbjerg, 2021). An individual's or a group's preferential judgement for one option, a particular weighting score or solution of a problem was categorised as personal bias. This is based on the decision maker's personal opinion (e.g., likes or dislikes) which may be founded on limited evidence. But these subjective judgements and preferences can also be a valid expert opinion based on considerable technical and commercial experience. The responses suggest that project managers recognise the influence of subjective biases and personal opinions in the decision-making process, even when working with quantitative data. For instance, the following statement was made by P13 *"It's quite interesting, we struggle with this sometimes because it obviously sounds very quantitative from the outside, as you've rightly already picked up is that it's quantitative when it comes out, but it is very much opinionated when you get to it."*

Responses indicate project managers would sometimes interpret a problem or solution in a manner that matches or agrees with previously held ideas but are then seeking out information to support this. As an example of confirmation bias, participant P14 stated – *"Sometimes it starts off and it's clearly someone just attempting to game the figures to get the answer that you know they wanted all along."*

Optimism bias is the tendency to overestimate the likelihood of experiencing positive events and underestimate the likelihood of experiencing negative events. According to P02 "*But every single time these are done, there's always wishful thinking done … So, yeah, there is a reluctance to look dispassionately at outcome costs and outcome schedules, because people think "oh, we'll do it better than that."*

Pattern recognition based on experience can also be referred to as sense-making because it involves thinking fast, based on recognition of a pattern of variation, selection and retention (Weick, 1995) and was therefore categorised as intuitive. Simon (1992) asserted that experience is accessibility to the information stored in memory, which can provide an answer or solution. Most (14 out of the 16) participants reported instances of using their experience (stored memory) to rapidly discern recognizable patterns when making decisions. Some quotes supporting this rapid recognition of patterns (e.g., rapid identification of option feasibility) are: *"Purely based on experience, yes, by and large. What typically happens is when you pull all the engineers into the room and you ask that question "does it pass the laugh test?" normally there is one option that everyone just stacks hands pretty quickly, "that just looks sensible."* P02

> *"At the concept select stage, you're optioneering anyway … And this is really where you get the experienced people in to say "well, hang on, that's not going to work" or "have you tried a bundle pipeline through route X, Y, and Z?" P03*

Holistic processing or view is being able to see the broader or big picture and focuses on looking at things as a whole and was categorised as intuitive. Participant P05 stated *"So, yes, there is room for experience, and very often in project decision making, making decisions based on your experience are actually quite sound, but of course that is assuming that you can see the big picture"*.

Gut feel/Sentiment was the third aspect of Intuitive decision making. According to Kahneman (2011), intuitive decision making is based on emotions, vivid imagery and associative memory. Responses from 12 participants suggested that project managers did use gut feel or sentiment in decision making at the front-end stage which was often associated with emotional states such as 'feeling comfortable' (or uncomfortable or uneasy). For example, Participant P08 used the term 'gut feeling' in relation to experience when he stated *"And he didn't know exactly what it would be like, but he knew enough to feel "I know there's a different way of doing this… we ended up reworking that on his initiative and leadership, … So, that's an example where somebody has a gut feeling that they might not know the final answer, but he just has a gut feeling that can't be the only way of doing it, and that comes through experience."*

Another participant, P12 supports the idea of gut feel by responding, *"I want to know what you think is going to happen, what is your gut feeling of where things are going? You can have the proper cost forecast and schedule forecast, but do you really think that's the truth? Is there something out there that you just don't feel all right about? That's that intuition. That's probably why I employ so many women in my projects, they've got good intuition for these things that are going to go wrong."* Apart from the reference to women, there were also innuendos that it is more acceptable for certain disciplines or professions to rely on their feelings and associated memory than others. Participant P14 stated - *"I think the management teams will use it [gut feel] more than the engineering teams. Ultimately, they might get asked to look at something, if they're not comfortable with it, they won't say they're not comfortable but they'll just tell you it's a stupid idea and it won't work … Probably not so much with the options to things … if the shape of the curve looks unusual or counter-intuitive, or just the spread of outcomes feels too tight or much, much too large, then words like 'gut feel' will start to come into it."*

These findings indicated that there was sufficient evidence to conclude that experienced project managers do, at times, use intuitive methods of decision making in the front-end stage of projects.

4.1.2. Analytical decision-making

This is a structured and systematic style of decision making, for example comparing a set of options using rating or ranking methods. Stanovich (2011) describes this approach as a way of information processing that involves slow thinking using high computational power. He states that one main function of this type of processing is to override the intuitive approach (p. 20). Because of the cognitive load that is required for analytical processing, typically exceeding the capacity of working memory (Baddeley, 1992), this type of decision making often requires the options and the available information on each one, plus the goal criteria to be visualized (e.g., as a decision matrix) using paper and pencil or a computer-based display. Within the interviews, there were many references to aspects of analytical decision making, although respondents rarely used this term. Since analytical decision-making processes are well acknowledged in large complex projects (Volden, 2019; Hazır, 2015) less attention was paid to this method, but three aspects were coded: Experience based on data, the use of software tools and optimizing. In total, 10 respondents talked about data-driven decision making, 12 described the use of software tools, and 4 respondents indicated that optimising occurred (Table 2).

Experience based on data or data driven decision-making refers to the use of available data and information to reach and/or back up a decision. It relates to gathering and processing information on options or aspects of a problem and consciously analysing that material, using past experience as a guide. Participant P07 stated *"So, you're not blind, there is data out there, and you can use it to provide weightings so you can make the right decisions that suit your company and your own appetite."*

The use of software indicates how PMs employ the use of formal decision analysis and computer-based support tools to make calculations and compare options. Participant P01 stated - *"And through the software, Monte Carlo simulations, then that gives you a curve. So, then you can look and see where your deterministic schedule is, is it a P10, is it a P15, is it a P90? If it's a P10, maybe you need to go away and do some more work, because you're being too optimistic on cost and schedule. But also, it's a good tool for management to say "right, okay, we're at P10 when we've looked at this."* However, some views about the use of software tools suggested possible limits to actually making decisions. For example, Participant P06 explained *"I would say we use software to almost visualise the decision rather than to help making it, if you like. So, these decision tables and just the way in which we assign weighting to different criteria and how we score the different options, that's often presented in an electronic form."*

Optimising is a decision-making strategy that aims for the best and most effective use of a situation or resource which requires having full information on each option and the time to engage in an extensive

consideration of these data. Some respondents suggested that project managers optimise in the front-end stage as they spend considerable time collecting more information to reach the best option to meet their cost targets. An example is P01 who explained the following:

> *"So, if you're negative in your low case, the decision might be made to go back and do some further work, …, so you might do some more seismic work or analysis of the reservoir. Or you might look at your capital costs and see if you can do some reduction … so rather than looking at what we need to produce the mid cases… you might go back and try and simplify the design, rather than looking at "right, this is the production the mid case is going to give us and this is what we should design for, let's look at what we gain for each capital investment."*

Some specific memorable decisions described by participants often occurred at the very early, concept phase, which can be characterized by limited or insufficient information. For example, intuitive decision-making is applied to quickly discount an option for pre-screening selection. Also, it was indicated that in option appraisal and evaluation of cost and schedule estimates, intuition can support an analytical approach. For instance, Participant 06 recalled a situation where the project's economics were not favourable, resulting in applying gut feeling to rework the analysis and coming up with a profitable option leveraging experience. In addition, intuitive thinking process were mentioned relating to technical decisions during the front-end phase in recognition of a familiar problematic task or clarifying a discrepancy in results from analytical software or tools. An example is when one respondent (P08) described a situation concerning a project on an offshore installation. A comprehensive analysis was done to discover the cause of a problem, including exploring insights through knowledge boards. Eventually, a workable solution was proposed, which fixed the issue, but nobody in the project team could explain it based on calculation or theory. On the other hand, analytical decisions were identified by respondents particularly relating to engineering processes in the pre project phase where there is sufficient data and information to use in the analysis. It was also said to be applied in the option appraisal/ evaluation phase to determine cost and schedule estimates.

4.1.3. Interplay between analytical and intuitive decision making

There were responses from ten participants that suggested the application of both types of decision making during the front-end phase. Cognitive psychologists generally believe that analytical and intuitive decision making are two coexisting information processing systems that interrelate, though they may be independent in the human brain (e.g., Evans, 2003). The sequential interplay between analytical and intuitive decision making was salient where participants explained that intuition had to be backed up with facts or numbers as the quotes illustrate.

> *"A lot of it is intuition. That's kind of why I've been trying to explain it in the way I have. Of course, a lot of it is analytical, a lot of it is based on really sound engineering. But a lot of the discussions we have at the sessions are intuitive. They go hand-in-hand. They have to. One goes with the other. It takes confidence, and it takes experience. And that's why it's really important to have the right people at these sessions," P03.*

> *"So, it's a bit of a blend of both, it's my skill and experiences of project managing and knowing that I need to deploy these tools and having organised those things to happen." P07*

There were also responses indicating that project managers switched back and forth between both types of decision-making processes (which they tended to label qualitative and quantitative) and when they take ''Educated Guesses'. The recognition that quantitative analyses may be based on more or less accurate information was also included here.

> *"…in the select phase when you're doing the concept select. …that phase is largely qualitative because you don't have a huge amount of information. Mostly qualitative with a little bit of quantitative based on benchmarks. When you move from the select phase into the define phase, which is the FEED, you typically have a lot more detail in which to make decisions, and the decisions start to become more quantitative rather than qualitative" P02.*

In a study of multi-attribute analytical decision methods used for decommissioning projects in oil and gas companies (Li & Hu, 2022), they noted that even with many formal decision techniques, there can be significant qualitative components with subjective elements, such as assigning weightings. There was also one reference to insight, which is sudden awareness of a solution or answer and involves experiential processing from established knowledge/information (Dane & Pratt, 2007). Lieberman (2000) explains that the use of insight occurs when one becomes aware of the logical relations between a problem and the solution. For example, Participant P05 mentioned this but went on to explain the importance of evidence: *"…there's room for expert insight? Yes, there is. But as this industry moves forward and as society moves forward, there is more a culture of exhibiting robustness that there is this documentary evidence that needs to be required."*

4.2. Decision-making drivers in the front-end of project management

The second research question considered the decision-making drivers during the front-end stage within complex projects. Our findings reveal a range of influencing factors which were categorised in a similar fashion to earlier studies (e.g., Montequín et al., 2018), i.e. into the five themes of project internal, and external factors, social dimensions, individual differences, and time pressure. These are shown in Table 3 with sub-themes and definitions, and they are considered more fully in the discussion section.

5. Discussion

In this section, the findings on front-end decision-making processes are considered in relation to the literature, followed by the role of the influencing factors. The discussion also identifies the study limitations and highlights the value of a naturalistic decision making research approach and the practical implications of the findings for project managers' decision making when working on complex projects.

5.1. How decisions are made in the front-end stage of projects

Due to the scale, intricacy and financial information involved in large scale complex projects, an analytical or rational decision-making process is the typical mode of decision making in the front-end stage (Li & Hu, 2022; Willian, 2010). This was confirmed by our interviewees who described various methods, such as a range of formal option comparison techniques which can involve rating or ranking (often supported by customized software packages). Many respondents emphasized the careful, deliberate search for information followed by analytical processes which were used to review and select options and then to make technical and financial decisions at the later front end stages before a Final Investment Decision (FID) gate (prior to implementation) was reached. It appears that the analytical processes are particularly relied upon at certain stages. For instance, in the pre-project phase (after the conceptual phase) advanced assessment and analysis is undertaken to develop the preferred option. It involves more of the physical engineering issues based upon the receipt of primarily quantitative data, as described by one project manager. At the concept phase of the front-end project information such as technical, cost, schedule and commercial risks is scarce (Williams et al., 2009). It is here that the analytical decision process tends to fall short. Olsson and Samset (2006) support the limited use of analytical tools at the early phases when projects are often initiated based on a preconceived idea of the technical solution.

Where options are analysed and selected, the decision making tends to depend more heavily on decision tools coupled with experience. This was supported by our findings as participants acknowledged the use of

Table 3
The result of the thematic analysis for factors influencing decisions in the front end (numbers indicate how many respondents mentioned the characteristic).

Theme	Sub Themes/Concept	Description
Project External Factors	Market condition (13)	Commerciality or state of the market relating to economic changes impacting on technical and cost feasibility (Montequín et al., 2018). Economic and Technical considerations (Klakegg et al., 2016). Contracting model in terms of the intricacies which increases the likelihood of weak contractual systems (Rezvani & Khosravi, 2019).
	Contractual factors (5)	
	Industry Norm: Benchmarking (4) and Data/ information management (6)	Standards for ensuring and maintaining best industry practices by using information quality feed (Eweje et al. 2012) and assessing projects to alleviate risks (Saputelli, Hull, & Alfonzo, 2008).
	Regulatory factors (6)	Government regulations which affect the project duration (Jergeas 2008). Also changes in national tax policies and custom duties etc. (Yau & Yang, 2012).
Project Internal Factors	Business imperatives (7)	The consideration of a strategic fit when selecting projects. Flyvbjerg (2021) refer to these as strategic misinterpretations.
	Company culture: Leadership & Empowering project team (7), Company risk acceptance (7), Blame culture (1)	Company's culture relating to responsibility and responsiveness of decision-making, risk appetite/ tolerance and leadership style (Turner, 2020).
	Company cashflow (7)	Financial standing of companies /a stable business cashflow (Mišić & Radujković, 2015).
Social Dimensions	Peer review (8)	Open mental process where team of reviewers generate various ideas/perspectives about a subject matter within a time frame (Saputelli & Black, 2013).
	Highest paid person's opinion (HIPPO) (7)	Top senior executives' ability to influence the decision making in a project due to their position (Marr, 2017).
	Partnership (5)	Trust issues in partnering and collaborative working (Kostis, 2022).
	Stakeholder alignment (6)	Stakeholders' complexity and alignment between project teams and other relevant stakeholders (Crawford 2005).
Individual Differences	Personality traits e.g., confidence (4) and individual risk appetite (1)	Behavioural factors comprising personality traits (Roberts et al., 2021) and those related to confidence and risk appetite (Kwak & LaPlace, 2005).
	Competence (4)	Project manager and team member skills and competence (Crawford, 2005).
Time Pressure	Accelerating projects (7)	Method used to fast-track projects, e.g., reducing lag/lead times (Zirger & Hartley, 1994).
	Analysis paralysis (3)	Getting less value from analysis than the time invested in the process (Eric Bickel & Bratvold, 2007).
	'Bike shedding' (3)	Tendency to spend a disproportionate amount of time on the less important things rather than attending to the more significant aspects of a project (Mcfedries, 2017).
	Taking shortcuts (4)	Circumventing processes or ignoring requirements to show a sense of a project's progression (Garber & Paté-Cornell, 2012).

'experience based on data', and the 'use of software'. In addition to the quantitative output being generated from these systems, project managers also utilized their experience to support a decision. Similarly, when Chenger and Woiceshyn (2021) examined front end decisions about major project ideas (acquisitions or greenfield developments), they found that, particularly in opportunistic cases, 'the executives were often able to make the front-end project decisions quickly with minimal analysis, based on substantial experience relevant to their major project concept. They did not need to build spreadsheets or perform formal analyses. They could easily and quickly complete a long-term cost/benefit analysis in their head' (p186). To address the challenge of using analytical tools to make decisions where information is limited, intuitive methods of decision making seem to be in use.

Naturalistic decision making research has revealed the ubiquity of fast, intuitive type methods of decision making by practitioners in a range of domains (Klein, 2022) and has been recommended for the study of project managers to examine the 'hidden' elements of their decision making, such as intuition (Stingl & Geraldi, 2021). This was supported by our findings. Although some participants had strong reservations about the use of intuition, the majority of them indicated that project managers sometimes rely on gut feel and pattern recognition when making decisions at the front-end stage. These types of decision making are based on considerable expertise and feedback on earlier decisions which build a rich knowledge base. However, some of the project managers were aware of the associated risks of heuristics and resulting cognitive biases (e.g., confirmation and optimism bias) which may lead to systematic errors in decision making (Tversky & Kahneman, 2004 pg. 203).

Use of gut feel has been argued to be useful in highly uncertain situations, such as investment decisions, where further information and analysis will not sway the original judgement, and it also inspires the leader to make a call (Huang, 2019) thus avoiding repeatedly re-analysing numerous options. This fast recognition of non-credible options may be more intuitive in nature than analytical. For the participants, gut feel, and pattern recognition based on experience appear to have a role in increasing confidence in numbers obtained from using an analytical tool e.g., Risk modelling and Monte Carlo simulations. In particular, pattern recognition based on experience seem to be useful in clearing incongruities in numbers from software/tools. The use of subject specialists may be relevant here as their experiences have been built up as memorized patterns which enables them to rapidly size up situations and make fast decisions without having to compare options (Klein et al., 2010).

Simon (1992) defined intuition as 'nothing more and nothing less than recognition' of patterns stored in the memory. He asserted that we are often not aware of the processes that accomplish the recognition and described the stored memories as an indexed encyclopaedia that forms an expert's behaviour (p 155). Kahneman and Klein (2009) argued that intuition can only be reliable if it reflects repeated experience in the specific environment with consistent feedback. Consequently, it has been recommended that intuition be supported by providing a broader

experience base that will enable individuals build tacit knowledge such as perceptual skills and richer mental models as means to reaching better decisions (Klein, 2015). In line with the findings of decision researchers (e.g., Evans, 2007; Kahneman, 2011), there were indications of a tendency for the project managers to switch back and forth between both types of decision-making processes. The interplay between intuitive and analytical decision-making processes by project managers has been previously reported (Leybourne & Sadler-Smith, 2006). As research with surgeons has shown (Moulton et al., 2010), part of the expert decision maker's skill is in recognising the cues in the situation that signal the need to slow down and switch to a more analytical mode.

Our findings indicate that project managers apply intuition, (based on experience and associative memory) for decision making at the more conceptual phases of the process where there is insufficient information, to initially discount an option, to increase confidence in numbers or clear inconsistencies and to detect familiar problems. These intuitive decision-making methods have not been extensively researched at the front end stage of project management even though they may be used to an extent before the analytical methods are introduced or used in combination. The exclusive focus on developing of analytical frameworks for decision analysis may result in an underestimation of some of the intuitive methods that are influencing project managers' judgements. Findings from the study align with the naturalistic decision-making literature that has studied other types of experienced professionals (Mosier et al., 2018; Klein, 2022).

Project managers not only employ analytical decision processes but also use intuitive methods based on sense making, pattern recognition and expert knowledge drawn from successful projects to inform project decisions. Decisions made by project professionals can also be impacted by emotions (Turner, 2021), bias (Flyvbjerg, 2021) and heuristics (Eriksson & Kadefors, 2017; Stingl & Geraldi, 2021), suggesting that sometimes there may be over-reliance on faster, instinctive methods instead of taking time to carefully deliberate on and analyse decisions. Boland (2008) mentions this combination of analytical and intuitive styles as an exciting prospect for organisational research. Our study adds to the weight of evidence indicating that a broader conceptualization of project managers' decision making in the front-end of complex projects is not only merited but necessary in order to have a full understanding of the decision processes that should be trained. The NDM methods, such as cognitive task analysis, are valuable tools for building the necessary evidence base.

5.2. Drivers of the front-end loading decision-making process

The second part of the thematic analyses examined the drivers influencing front-end decisions. The main categories which emerged related to factors external and internal to the organisation, social aspects, individual differences in project managers and time constraints. These echoed the main types of factors found in previous studies which had investigated influences on project managers' decisions (e.g., Stingl & Geraldi, 2017) or more generally on project success (e.g., Flyvbjerg et al., 2017; Serrador & Turner, 2015).

5.2.1. Project external factors

Market conditions were frequently mentioned. The volatility of a sector (in this case the oil and gas industry) seems to determine, to a large extent, decision making during the front-end stage. Oil and gas projects are usually strategically ranked based on pre-determined criteria, but the outcomes are significantly impacted by the market conditions. The decision-making processes employed can vary in different business terrains and economic conditions, such as the 'hot market', when a company's goal is to rapidly generate maximum return on investment on a project. The quality of decision-making may be impacted in this situation. A participant (P13) stated that, one of the biggest drivers of bad decision making is a hot market and explained the decision quality plummets when commercial activity is thriving. The same can be argued for other types of large-scale complex projects. Montequin et al. (2018) identified economic changes as factors linked to project failures in complex projects, though it had a comparatively low frequency index.

Respondents identified contractual factors as another area that requires scrutiny to determine the influences affecting decision making in the front-end phase. For example, the level of redundancy in cost, price and schedule built into the contract heavily dictate how fast and cautiously a project is executed. Anthopoulos et al. (2016) and Al Nahyan et al. (2012) pointed out that one way in which contractual issues can emerge is when stakeholders initiate contracts based on their personal goals; thus, giving rise to inadequate and futile coordination and poor information sharing amongst project parties. The contracting model between the client and operator was also mentioned as significantly influencing the complexity of the decision-making process at the front-end phase. For instance, the contractual agreement between parties could contain clauses that enable the clients to change elements in the contract dictated by the business environment. According to Salas (2015), the nature of contracting, and presence of uncertainty contribute to the seeming challenges confronting project owners when presenting management plans. Also, the very nature of a complex project indicates that many contractors and sub-contractors are involved in an intricate relationship, which often causes deficiencies in contractual agreements (Rezvani & Khosravi, 2019).

The industry norms are a crucial influence in decision-making. For oil and gas projects, the specific elements of industry norms stated by respondents are benchmarking and data/information management of projects, such as the Net Present Value (NPV) and Internal Rate of Return (IRR). Industry norms and issues around data sharing were discussed by more than half of the participants. According to Saputelli et al. (2008), project decisions consider insight into prevailing industry best practices and comparison amongst projects to enhance project success outcomes and mitigate risks. Complex projects require quality data availability at the front end stage for project manager's decision making to avoid unrealistic cost and schedule estimates which lead to an increase in cost and jeopardy of project quality at the later phase of the project (Gachter & Marton, 2020; Eweje et al., 2012).

Other influences such as political, regulatory, stakeholder buy-in and compliance, which have little or no considerations for the technical or commercial impacts of projects strongly influence the decision-making during a project. Government regulations could extend a project's duration as these are always not duly considered at the project initiating phase (Jergeas, 2008). Changes in local and national tax policy, in custom duties on imported equipment and goods (Yau & Yang, 2012), and changes in the policies of regulatory bodies are likely to affect project costing and revenue (Thamhain, 2013) which would influence the decision making.

5.2.2. Project internal factors

The internal factors impacting decision-making in the front-end phase of oil and gas projects, were similar to those found for complex projects in other sectors. The business imperatives which are contained in the company's strategic objectives were identified as key influences by about half of the respondents who discussed that some companies make decisions which may yield lower economic value but are better strategic fit and represent the company's value proposition. Business imperatives relate to Flyvbjerg's (2021) strategic misinterpretation, where a project's benefits are overestimated so that it is more desirable for a strategic purpose over competitors. Other influences on decisions made by project managers included strategic alignment of the project portfolio and ongoing concurrent projects that take precedence for organisations.

The company's culture relating to responsibility and responsiveness of decision-making, risk appetite/tolerance and leadership style was found to be another key internal factor, as previously noted by Turner (2020) and observed in the construction industry (Nyugen & Watanbe,

2017). A facet revealed in the interviews is the risk of the allocation of blame when the decision made goes wrong (also found by Roberts et al. (2021) in relation to technology adoption decisions). Although, one respondent said that he was more likely to criticise tardiness in project managers' decision making rather than assign blame to a decision made in a timely manner that turned out to be sub-optimal. Eweje et al. (2012), similarly highlight, from an organisational culture point of view, that project managers make decisions based on the information provided by the organisation and whether they perceive a challenge to be a threat or opportunity.

The financial standing of companies was identified as another key internal consideration to making decisions. This factor is parallel with the financial reasons discussed by Rezvani and Khosravi (2019) in their review of failure factors in large scale complex projects. Cash flows are essential parameters in the decision criteria requiring different models for cash generation as budget constraints for major capital-intensive projects may result in lost time at the decision gate. For example, a cash-flow-constrained or heavily indebted company will be more cautious about making decisions during a project. The reference to cash flow by half of the respondents is an indication of the importance financial budgets of companies (Mišić & Radujković, 2015; Gamble & Allport, 2015) and how it could contribute to the decision-making imperatives employed during the front-end phase to achieve success.

5.2.3. Social dimensions

The decision-making process at the front-end phase is a complex phenomenon that is often impacted by social elements. Interview participants described various social dimensions that impact decision-making. These can be in the form of peer review, Highest Paid Person's Opinion (HiPPO), partnership/trust consideration, and stakeholder alignment techniques.

The peer scrutiny process (e.g., project review, independent internal and external reviews), is where other team members or individuals external to the project are drafted in to evaluate the project's progress. In complex infrastructure projects, the decision-makers rely on the project review to ascertain the technical justification of the project. During the life of a project, more often than not, the team is fused with a team of reviewers to provide varying perspectives through the review process (Saputelli & Black, 2013). Review processes are assessments by project professionals to eliminate bias and errors (Flyvbjerg, 2009). Arguably, the decision outcome of this process varies with the people in the room with regards to the level of knowledge and experience of technical aspects (Thamhain, 2013) and the desired project strategic purpose (Flyvbjerg, 2017).

The HiPPO factor is characterised by the influence accrued, via the positional or psychological power, that an individual (or sets of individuals) exert to achieve their goals at the detriment or expense of others. Consequently, if the decisions are impacted by the HiPPO syndrome (e.g., the most senior manager over-ruling a team decision), this could result in future significant project problems if they are inaccurate or erroneous. This is mostly evident when the analytical process is insufficient, thereby necessitating the need to rely on the experiences and consensus of others. Marr (2017) opines that the HiPPO effect is a significant barrier to analytical decision making because the influence of an expert's judgement could stem from personal bias or interest as opposed to pattern recognition based on experience.

Alignment or misalignment amongst partners resulting from trust or distrust is another factor impacting the decision-making of a project, especially for joint venture organisations with two or more partners. The importance of trust is a well-established variable in the project management literature (e.g., Kostis et al., 2022). The interdependence and trust, such as multi-stakeholder partnerships and a need for stakeholder alignment, portends more intricacies to decision-making. The alignment or otherwise between the project teams and other important stakeholders (Crawford 2005) would dictate how and when decisions are made. Basically, if there is no early alignment, a project team's efforts will be delayed or stalled until alignments are reached to eliminate/reduce recycles.

5.2.4. Individual differences

Interview participants identified individual factors, namely competence and personality traits, as influences on decision making. These relate to project professionals, managers and also the ability and style of the project team (e.g., solution or problem-focused) and they are well documented as key influences on complex project management (Belassi & Tukel, 1996; Montequín et al., 2018). It did appear that the most senior project managers in our sample were more prepared to admit to using intuitive methods than those of less experience who tended to strongly emphasise the necessary rigour of formal analytical methods. But given the small sample size, this observation would need to be properly tested.

In relation to skills development, it was surprising that only three of the project managers had received training in decision making. This was an unexpected finding, given the importance of decision-making skills for project managers and the enormous cost of failure. It may be worth noting that the OGA (2017) report concluded 'Project management is a profession increasingly recognised for the value it brings.' However, despite an increase in processes, tools, project controls, supervision and engineering man-hours, there has been no visible improvement in the ability to predict outcomes.' (p12). This could be one reason for the relatively recent focus on behavioural aspects in decision making in projects.

Personality traits, thought by the interviewees to be influential were related to confidence and risk appetite. Project managers' level of risk tolerance is already known to have an influencing effect on their decisions (Kwak & LaPlace, 2005; OGA, 2017). Awareness of the influence of these behavioural traits in self and others and techniques for their management could be included in decision training for project managers.

5.2.5. Time pressures

In complex projects, the team is usually under pressure to deliver to cost and schedule to achieve maximum value for the projects. Time pressure was mentioned by several participants, for example acceleration of projects, 'analysis paralysis', 'bike-shedding' and taking shortcuts. There are instances where project schedules are collapsed to achieve early first oil production, hence, fundamental steps or stages could be fast-tracked or totally expunged to meet the objectives (Zirger & Hartley, 1994). However, the relationship between accelerating projects and value creation is not well established in the literature (Svejvig et al., 2019).

Furthermore, the pace of exchange of information and data between teams (internally and externally) can also be important factors, as mentioned by respondents. Teams spend enormous time to gather and transfer data which may not have additional benefit to the project's objectives. Project schedule delays could also result from lags in obtaining necessary information to progress the project and over-analysis to understand the problem to reduce uncertainties and reach a place of comfort. Eric Bickel and Bratvold (2007) study showed that technical professionals believe that the project times are usually too short for decision analysis to be totally followed and they argued that the value from analysis outcome is less than the effort invested in the analysis.

The term 'bike-shedding' aligns with Parkinson's Law of Triviality (Mcfedries, 2017) where project managers tend to focus on the wrong things which may be easier to deal with and/or to appear busy. Taking shortcuts is associated with the principal-agent theory, where either the agent or the principal avoids following the procedures strictly and cuts corners to give an illusion that the project is progressing (Garber & Paté-Cornell, 2012).

In summary, adopting a naturalistic, descriptive orientation in the interview process allowed a wide range of influences to be revealed for

front end decision making, already echoed in the findings of earlier research (e.g., Montequin et al., (2018); Mišić and Radujković (2015); Flyvbjerg (2011, 2017); Lefley (2006)). The method also helped to reveal that intuitive modes of decision making are being used alongside analytical approaches by experienced project managers, and often they switch between the two modes of thinking. The study shows how the NDM method is useful for practice-based inquiries as it explores how experienced professionals make decisions in their environment. The theoretical contribution for the broader project management field is a fuller understanding of the decision making process in the front end of projects so that project managers are appropriately trained in decision making established on what actually happens in their environment.

6. Limitations and future directions

Qualitative research aims to explore the meaning and processes of the respondents' experience in order to gain an in-depth understanding of a phenomenon or a situation (Taylor, Bogdan, & DeVault, 2015). This is appropriate for a preliminary study, such as that reported here, which has provided indicative findings to guide future investigations. Cognitive processes are not directly observable and deducing modes of decision making from self-report accounts can be difficult but there did appear to be evidence from our interview data for the use of intuitive decision processes, as well as the better-known analytical methods. The critical decision method, which has been advocated by others to investigate project managers' decision making (e.g., Stingl & Geraldi, 2021; Turner 2020) does appear to have potential, although requiring a degree of customization to the domain. A future avenue for research would be to examine the possible interaction between decision drivers and types of cognitive processing. The extent to which the factors influencing decision making style and quality overlap with those influencing project success remains to be determined.

The front-end phase usually takes a relative long period of time for a large-scale complex project, during which project managers make numerous decisions to move the project forward. It may be instructive to focus on the particular components of the front end (e.g., the pre study or pre project phase (Fig. 1)), as our findings had early indications that the balance of analytical and intuitive may be stage dependant. Important contextual factors may link with the way individuals perceive the outcome of a decision-making process and this research question could be approached using an observational study, coupled with a longitudinal design. Another limitation lies in the descriptive nature of our preliminary study. A quantitative approach (e.g., a questionnaire survey) would enable the postulated intervening role of decision making (Elbanna, 2015; Turner, 2020) between influences and project management outcomes to be modelled.

Given the fact that large scale complex projects have, in general, similar characteristics in terms of their long and critical front end and strategic depth (Miller & Hobbs, 2005; Eweje et al., 2012), the findings are applicable to complex projects in other sectors. Experienced project practitioners are likely to use intuition based on pattern recognition gained from their years of experience. However, there is need for comparative case studies with other industries because oil and gas projects tend to have more technical complexities and aggressive schedules than their counterparts in other sectors (Merrow, 2012) and because the study was conducted on a small sample size working on UK offshore projects.

Further research would be of benefit to develop a conceptual framework that indicates when decision errors are likely to occur and how the intuitive and analytical processes may be integrated to assist experienced project managers at the front-end stage of complex projects. Flyvbjerg (2021, pg. 543) recently argued for more understanding of social and cognitive processes, concluding, "the behavioural revolution seems to be here to stay, and it entails an important change of perspective for project management."

7. Conclusion and recommendation

The evidence gathered from the project managers' accounts of decision making indicated that there were elements of intuitive decision making (e.g., pattern-recognition based on experience and the influence of feelings and associative memory) that were being used alongside the formal analytical processes, often based on software tools. This finding adds weight from a different industrial domain to a growing body of evidence that experienced project managers have skills relating to intuitive decision processes and that more attention should be paid to the role of these processes which can be used in conjunction with analytical methods. The project managers appeared to be aware of the risks of decision errors, from influences such as confirmation bias or personal preferences which may be more common in an intuitive mode. In addition, the range of factors that could influence the quality of project management decisions in the front end stage were similar to those reported in other domains, with both external and internal drivers. How exactly these factors relate to specific decision processes in complex project management was beyond the scope of this investigation and remains to be determined.

This study shows the value of adopting a naturalistic decision making approach, which recognises a full range of cognitive processes, to explore and describe decision making in the front end of complex projects. Understanding how intuitive and analytical methods operate and when best to utilise them should be one objective of decision training for project managers, along with teaching on how to recognise influencing factors, especially the less obvious behavioural drivers. Our study findings highlight the need to broaden our understanding of decision making at the front end of complex projects so that project managers are appropriately trained on decision making based on what actually happens in their environment and the factors that are likely to influence decision making. By extending the knowledge about intuitive decision making occurring at the front end of projects, we propose that PMs should be taught how to recognise when intuitive decision making is taking place and how to spot and use it, knowing that it has strengths and weaknesses, in order to assess the resulting decisions.

Across industries, project managers have to make complex, risky, expensive decisions under time pressure. Decision training for these project managers needs to convey how and when intuitive processes can complement the more formal, analytical techniques.

Declaration of Competing Interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: The authors received financial support for the research. The Engineering Construction Industry Training Board, United Kingdom, funded the study. There was no conflict of interest with respect to the authorship of this article or no known personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgement

This research was funded by the Engineering Construction Industry Training Board, United Kingdom.

Appendix 1 Interview questions

A. **Demographic questions**
   1. How many years have you worked in upstream oil and gas production?
   2. How many years were you acting in a senior manager capacity?
   3. Roughly How many oil and gas capital projects have you managed at the FEL phase or before the project is sent out for sanction or Technical Bid Evaluation (TBE)?

B. **General view of front-end loading stage**

1. Are you familiar with the project management term "Front-End Loading"? If so, what does this mean to you?
2. What is the front-end loading process in your organisation?
3. What is the nature of your decision-making in the FEL phase?
4. Do you make decisions on a single-phase or all the phases of the FEL project?
5. What are the key technical decisions (decision gate) taken on the main FEL stages?

C. **Questions on the interviewee's experience in FEL stage and oil and gas industry**

1. What, if any, are the pressures that influence decisions at the Front-end loading phases? Are there any other pressures influence the Front-end loading phases (e.g., external and internal)?
2. During decision-making, how do you come up with possible options?
3. How do you select the preferred alternative?
4. How are the attributes for options decisions selected and weighted?
5. Have you experienced any situations where the preferred alternative was not selected? If so, please describe.
6. Have you had formal training on how to make decisions for project management? If so, what did this consist of?

D. **Focus here on one decision – critical decision method.**

1. Please think of a particularly memorable and challenging decision that you have had to make during the front-end stage of an O&G project.
2. Can you please describe the situation in which you had to make this decision? (e.g., type and location of project, scale, time, risk, those involved).
3. Now describe your thought processes in making this decision (e.g., information, information sources, priorities, experience, influencing factors, method, use of decision tools).

References

Alderman, N., Ivory, C., McLoughlin, I., & Vaughan, R. (2005). Sense-making as a process within complex service-led projects. *International Journal of Project Management, 23*(5), 380–385.

Alimadadi, S. (2022). A pragmatist perspective on front-end project organizing: The case of refurbishment of the Palace of Westminster. *International Journal of Project Management, 40*(7), 763–777.

Al-Harbi, K. M. A. (2001). Application of the AHP in project management. *International Journal of Project Management, 19*(1), 19–27. https://doi.org/10.1016/S0263-7863(99)00038-1

Al Nahyan, M. T., Sohal, A. S., Fildes, B. N., & Hawas, Y. E. (2012). Transportation infrastructure development in the UAE: Stakeholder perspectives on management practice. *Construction Innovation, 12*(4), 492–514.

Andersen, B., Samset, K., & Welde, M. (2016). Low estimates–high stakes: Underestimation of costs at the front-end of projects. *International Journal of Managing Projects in Business, 9*(1), 171–193.

Anthopoulos, L., Reddick, C. G., Giannakidou, I., & Mavridis, N. (2016). Why e-government projects fail? An analysis of the Healthcare.gov website. *Government Information Quarterly, 33*(1), 161–173.

Artto, K., Ahola, T., & Vartiainen, V. (2016). From the front end of projects to the back end of operations: Managing projects for value creation throughout the system lifecycle. *International Journal of Project Management, 34*(2), 258–270.

Babaei, M. A., Locatelli, G., & Sainati, T. (2021). What is wrong with the front-end of infrastructure megaprojects and how to fix it: A systematic literature review. *Project Leadership and Society, 2*, Article 100032.

Baddeley, A. (1992). Working memory. *Science (New York, N.Y.), 255*, 556–559.

Bazerman, M. H., & Moore, D. A. (2017). *Judgment in managerial decision making*. John Wiley & Sons.

Bearman, C., Paletz, S., & Orasanu, J. (2009). Situational pressures on aviation decision making: Goal seduction and situation aversion. *Aviation, Space and Environmental Medicine, 80*(6), 556–560.

Belassi, W., & Tukel, O. I. (1996). A new framework for determining critical success/failure factors in projects. *International Journal of Project Management, 14*(3), 141–151.

Boland, R. J. (2008). Decision making and sensemaking. *Handbook on decision support systems 1* (pp. 55–63). Berlin: Springer.

Blomquist, T., Hällgren, M., Nilsson, A., & Söderholm, A. (2010). Project-as-practice: In search of project management research that matters. *Project Management Journal, 41*(1), 5–16.

Burke, L. A., & Miller, M. K. (1999). Taking the mystery out of intuitive decision making. *Academy of Management Perspectives, 13*(4), 91–99.

Byrne, D. (2022). A worked example of Braun and Clarke's approach to reflexive thematic analysis. *Quality & Quantity, 56*(3), 1391–1412.

Chakkol, M., Selviaridis, K., & Finne, M. (2018). The governance of collaboration in complex projects. *International journal of operations & production management, 38*(4), 997–1019.

Chenger, D., & Woiceshyn, J. (2021). Executives' decision processes at the front end of major projects: The Role of context and experience in value creation. *Project Management Journal, 52*(2), 176–191.

Calabretta, G., Gemser, G., & Wijnberg, N. M. (2017). The interplay between intuition and rationality in strategic decision making: A paradox perspective. *Organization Studies, 38*(3–4), 365–401.

Cicmil, S. (2006). Understanding project management practice through interpretative and critical research perspectives. *Project Management Journal, 37*(2), 27–37.

Cicmil, S., Cooke-Davies, T., Crawford, L., & Richardson, K. (2017). Exploring the complexity of projects: Implications of complexity theory for project management practice. *Project Management Institute*.

Clark, R., Feldon, D., van Merrienboer, J., Yates, K., & Early, S. (2008). Cognitive task analysis. In J. Spector, M. Merrill, J. van Merriënboer, & M. Driscoll (Eds.), *Handbook of research on educational communications and technology* (3rd ed.). Mahwah, NJ: Lawrence Erlbaum Associates.

Clarke, V., & Braun, V. (2017). Commentary: Thematic analysis. *Journal of Positive Psychology, 12*(3), 297–298.

Cohen, C. B. (2005). *Project management decision making: Blending analysis and intuition. paper presented at PMI® global congress 2005—Latin America*. Panama City, Panama. Newtown Square, PA: Project Management Institute. Available at https://www.pmi.org/learning/library/pm-decision-making-analysis-intuition-7492.

Cooper, R. G., & Kleinsehmidt, E. J. (1995). Benchmarking firms' new product performance and practices. *IEEE Engineering Management Review, 23*(3), 112–120.

Crandall, B., Klein, G., & Hoffman, R. (2006). *Working minds: A practitioner's guide to cognitive task analysis*. Cambridge. MA: MIT Press.

Cravens, J. (2017). The opportunity for improved development of new gas projects. [online]. *Power Engineering*. Available at< https://www.power-eng.com/om/the-opportunity-for-improved-development-of-new-gas-projects/#gref> [*Accessed* 11 *March* 2022].

Crawford, L. (2005). Senior management perceptions of project management competence. *International Journal of Project Management, 23*(1), 7–16.

Croskerry, P. (2013). From mindless to mindful practice—Cognitive bias and clinical decision making. *New England Journal of Medicine, 368*(26), 2445–2448.

Dane, E., & Pratt, M. G. (2007). Exploring intuition and its role in managerial decision making. *Academy of Management Review, 32*(1), 33–54.

Davies, A., & Mackenzie, I. (2014). Project complexity and systems integration: Constructing the London 2012 Olympics and Paralympics Games. *International journal of project management, 32*(5), 773–790.

Denicol, J., Davies, A., & Krystallis, I. (2020). What are the causes and cures of poor megaproject performance? A systematic literature review and research agenda. *Project Management Journal, 51*(3), 328–345.

Denney, D. (2006). Stage-gate project-management process in the oil and gas industry. *Journal of Petroleum Technology, 58*(12), 68–71.

Edkins, A., Geraldi, J., Morris, P., & Smith, A. (2013). Exploring the front-end of project management. *Engineering Project Organization Journal, 3*(2), 71–85.

Elbanna, S. (2015). Intuition in project management and missing links: Analyzing the predicating effects of environment and the mediating role of reflexivity. *International Journal of Project Management, 33*(6), 1236–1248.

Elliott, V. (2018). Thinking about the coding process in qualitative data analysis. *The Qualitative Report, 23*(11), 2850–2861.

Eric Bickel, J., & Bratvold, R. B. (2007). Decision Making in the Oil and Gas Industry: From Blissful Ignorance to Uncertainty-Induced Confusion. *SPE Annual Technical Conference and Exhibition?* (pp. SPE–109610). SPE.

Eriksson, T., & Kadefors, A. (2017). Organisational design and development in a large rail tunnel project—Influence of heuristics and mantras. *International Journal of Project Management, 35*(3), 492–503.

Evans, J. (2007). *Hypothetical Thinking: Dual Processes in Thinking and Judgement*. Hove: Psychology Press.

Evans, J. S. B. (2003). In two minds: Dual-process accounts of reasoning. *Trends in Cognitive Sciences, 7*(10), 454–459.

Evans, J. S. B. (2019). Reflections on reflection: The nature and function of type 2 processes in dual-process theories of reasoning. *Thinking & Reasoning, 25*(4), 383–415.

Eweje, J., Turner, R., & Müller, R. (2012). Maximizing strategic value from megaprojects: The influence of information-feed on decision-making by the project manager. *International Journal of Project Management, 30*(6), 639–651.

Flyvbjerg, B. (2021). Top ten behavioral biases in project management: An overview. *Project Management Journal, 52*(6), 531–546.

Flyvbjerg, B., Garbuio, M., & Lovallo, D. (2017). Delusion and deception in large infrastructure projects: Two models for explaining and preventing executive disaster. *Defense AR Journal, 24*(3), 583–585.

Flyvbjerg, B. (2013). Quality control and due diligence in project management: Getting decisions right by taking the outside view. *International Journal of Project Management, 31*(5), 760–774.

Flyvbjerg, B. (2011) "Over budget, over time, over and over again," Oxford HandbooksOnline [Preprint]. Available at: https://doi.org/10.1093/oxfordhb/9780199563142.003.0014 [Accessed 19 March 2022].

Flyvbjerg, B. (2009). Optimism and misrepresentation in early project development. *Making essential choices with scant information* (pp. 147–168). London: Palgrave Macmillan.

Gamble, K. F., & Allport, C. D. (2015). The impact of disclosing, management's past forecast accuracy on nonprofessional investors' heuristic decision-making. *Academy of Accounting and Financial Studies Journal, 19*(2), 103.

Garber, R., & Paté-Cornell, E. (2012). Shortcuts in complex engineering systems: A principal-agent approach to risk management. *Risk Analysis: An International Journal, 32*(5), 836–854.

Geraldi, J., & Söderlund, J. (2018). Project studies: What it is, where it is going. *International Journal of Project Management, 36*(1), 55–70.

Gore, J., Banks, P., & McDowall, A. (2018). Developing cognitive task analysis and the importance of socio-cognitive competence/insight for professional practice. *Cognition, Technology & Work, 20*(4), 555–563.

Guest, G., Bunce, A., & Johnson, L. (2006). How many interviews are enough? An experiment with data saturation and variability. *Field methods, 18*(1), 59–82.

Haji-Kazemi, S., Andersen, B., & Krane, H. P. (2013). Identification of early warning signs in front-end stage of projects, an aid to effective decision making. *Procedia-Social and Behavioral Sciences, 74*, 212–222.

Hayashi, A. M. (2001). When to trust your gut. *Harvard Business Review, 79*(2), 59–65.

Hazır, Ö. (2015). A review of analytical models, approaches and decision support tools in project monitoring and control. *International Journal of Project Management, 33*(4), 808–815.

Heising, W. (2012). The integration of ideation and project portfolio management—A key factor for sustainable success. *International Journal of Project Management, 30*(5), 582–595.

Hodgkinson, G. P., & Sadler-Smith, E. (2018). The dynamics of intuition and analysis in managerial and organizational decision making. *Academy of Management Perspectives, 32*(4), 473–492.

Huang, L. (2019). When it's OK to trust your gut on a big decision. [online]. *Harvard Business Review*. Available at: < https://hbr.org/2019/10/when-its-ok-to-trust-your-gut-on-a-big-decision> [*Accessed* 11 *March* 2022].

Huff, R. A., & Prybutok, V. R. (2008). Information systems project management decision making: The influence of experience and risk propensity. *Project Management Journal, 39*(2), 34–47.

Jergeas, G. (2008). Analysis of the front-end loading of Alberta mega oil sands projects. *Project Management Journal, 39*(4), 95–104.

Joslin, R., & Müller, R. (2016). The relationship between project governance and project success. *International Journal of Project Management, 34*(4), 613–626. https://doi.org/10.1016/j.ijproman.2016.01.008

Jugdev, K., & Moller, R. (2006). A retrospective look at our evolving understanding of project success. *IEEE Engineering Management Review, 34*(3), 110-110.

Kahneman, D. (2011). *Thinking, fast and slow*. London: Allen Lane.

Kahneman, D., & Klein, G. (2009). Conditions for intuitive expertise. A failure to disagree. *American Psychologist, 64*(6), 515–526.

Klakegg, O. J., Williams, T., & Shiferaw, A. T. (2016). Taming the 'trolls': Major public projects in the making. *International Journal of Project Management, 34*(2), 282–296.

Jonny Klakegg, O (2009). Pursuing relevance and sustainability: Improvement strategies for major public projects. *International Journal of managing projects in business, 2*(4), 499–518.

Klein, G. (2022). *Snapshots of the mind*. Cambridge, Mass: MIT Press.

Klein, G. (2015). A naturalistic decision-making perspective on studying intuitive decision making. *Journal of Applied Research in Memory and Cognition, 4*(3), 164–168.

Klein, G. (1993). A recognition-primed decision (RPD) model of rapid decision making. In G. Klein, J. Orasanu, R. Calderwood, & C. Zsambok (Eds.), *Decision making in action*. New York: Ablex.

Korteling, J., Gerritsma, J., & Toet, A. (2021). Retention and transfer of cognitive bias mitigation interventions: A systematic literature study. *Frontiers in Psychology*, 3402.

Kostis, A., Bengtsson, M., & Näsholm, M. H. (2022). Mechanisms and dynamics in the interplay of trust and distrust: Insights from project-based collaboration. *Organization Studies, 43*(8), 1173–1196.

Kvale, S., & Brinkman, S. (2008). *Interviews*. London: Sage.

Kwak, Y., & LaPlace, K. (2005). Examining risk tolerance in project-driven organization. *Technovation, 25*(6), 691–695.

Lefley, F. (2006). Can a project champion bias project selection and, if so, how can we avoid it? *Management Research News, 29*(4), 174–183. https://doi.org/10.1108/01409170610665031

Leybourne, S., & Sadler-Smith, E. (2006). The role of intuition and improvisation in project management. *International Journal of Project Management, 24*(6), 483–492.

Li, Y., & Hu, Z. (2022). A review of multi-attributes decision-making models for offshore oil and gas facilities decommissioning. *Journal of Ocean Engineering and Science, 7*, 58–74.

Lieberman, M. D. (2000). Intuition: A social cognitive neuroscience approach. *Psychological Bulletin, 126*(1), 109.

Lipshitz, R., Klein, G., Orasanu, J., & Salas, E. (2001). Taking stock of naturalistic decision making. *Journal of Behavioral Decision Making, 14*(5), 331–352.

Loosemore, M., & Cheung, E. (2015). Implementing systems thinking to manage risk in public private partnership projects. *International Journal of Project Management, 33*(6), 1325–1334.

Luoma, J., & Martela, F. (2021). A dual-processing view of three cognitive strategies in strategic decision making: Intuition, analytic reasoning, and reframing. *Long Range Planning, 54*(3), Article 102065.

Marr, B. (2017). Data-driven decision making: Beware of the HIPPO effect! [online]. *Forbes, at*. Available https://www.forbes.com/sites/bernardmarr/2017/10/26/data-driven-decision-making-beware-of-the-hippo-effect/?sh=731086f480f9 [Accessed 11 March 2022].

Martinsuo, M. M., Vuorinen, L., & Killen, C. (2019). Lifecycle-oriented framing of value at the front end of infrastructure projects. *International journal of managing projects in business, 12*(3), 617–643.

McClory, S., Read, M., & Labib, A. (2017). Conceptualising the lessons-learned process in project management: Towards a triple-loop learning framework. *International Journal of Project Management, 35*(7), 1322–1335.

Mcfedries, P. (2017). Agile words [technically speaking]. *IEEE Spectrum, 54*(6), 21-21.

Merrow, E. W. (2012). Oil and gas industry megaprojects: Our recent track record. *Oil and Gas Facilities, 1*(02), 38–42.

Miller, R., & Hobbs, B. (2005). Governance regimes for large complex projects. *Project Management Journal, 36*(3), 42–50.

Mišić, S., & Radujković, M. (2015). Critical drivers of megaprojects success and failure. *Procedia Engineering, 122*, 71–80.

Montequín, R. V., Balsera, V. J., Fernández, C., & Fernández, O. F. (2018). Exploring project complexity through project failure factors: Analysis of cluster patterns using self-organizing maps. *Complexity*.

Morris, P. (2011). Managing the front-end: Back to the beginning. *Project Perspectives, 33*, 4–9.

Mosier, K., Fischer, U., Hoffman, R., & Klein, G (2018). Expert professional judgments and "naturalistic decision making. In K. Ericsson, R. Hoffman, A. Kozbelt, & A. Williams (Eds.), *The Cambridge handbook of expertise and expert performance*. Cambridge University Press.

Moulton, C. A., Regehr, G., Lingard, L., Merritt, C., & MacRae, H. (2010). Slowing down when you should': Initiators and influences of the transition from the routine to the effortful. *Journal of Gastrointestinal Surgery, 14*(6), 1019–1026.

Mullaly, M. (2014). The role of agency in project initiation decisions. *International Journal of Managing Projects in Business, 7*(3), 518–535.

Murphy, S. A., & Kumar, V. (1997). The front end of new product development: A Canadian survey. *R&D Management, 27*(1), 5–15.

Musca, G. N., Mellet, C., Simoni, G., Sitri, F., & De Vogüé, S. (2014). Drop your boat!": The discursive co-construction of project renewal. The case of the Darwin mountaineering expedition in Patagonia. *International Journal of Project Management, 32*(7), 1157–1169.

Gachter, R., & Marton, A. (2020, November). Leading Capital Projects to Repeatable Success. In *Abu Dhabi International Petroleum Exhibition and Conference* (p. D041S108R003). SPE.

Nava, T. & Rivolta, T. (2013). Large project management in oil and gas: Bain and company. Report. Available from: https://media.bain.com/Images/BAIN_BRIEF_Large_project_management_in_oil_and_gas.pdf [Accessed 15th April 2022].

Newman, D., et al. (2020). Can 1hr training improve decision making? *European Journal of Decision Processes, 8*, 89–124.

Nguyen, L. H., & Watanabe, T. (2017). The impact of project organizational culture on the performance of construction projects. *Sustainability, 9*(5), 781.

Nobelius, D., & Trygg, L. (2002). Stop chasing the front end process—Management of the early phases in product development projects. *International Journal of Project Management, 20*(5), 331–340.

Oil and Gas Authority. (2017). Lessons learned from UKCS oil and gas projects 2011-2016. [online] Available at: https://www.nstauthority.co.uk/media/3380/oga-lessons-learned-from-ukcs-oil-and-gas-projects-2011-2016.pdf [Accessed 15 April 2022].

Olsson, N., & Samset, K. (2006). Front-end management, flexibility, and project success. In *PMI research conference proceedings* (pp. 17–19).

Parth, F. R. (2013). *Critical decision-making skills for project managers*. Istanbul, Turkey. Newtown Square, PA: Project Management Institute.

Pauley, K., Flin, R., Yule, S., & Youngson, G. (2011). Surgeons' intraoperative decision making and risk management. *American Journal of Surgery, 202*(4), 375–381.

Rezvani, A., & Khosravi, P. (2019). Identification of failure factors in large scale complex projects: An integrative framework and review of emerging themes. *International Journal of Project Organisation and Management, 11*(1), 1–21.

Roberts, R., Flin, R., Millar, D., & Conradi, L. (2021). What use is technology if no one uses it? The psychological factors that influence technology adoption decisions in oil and gas. *Technology, Mind, and Behavior, 2*(1). https://doi.org/10.1037/tmb0000027

Sadler-Smith, E., & Shefy, E. (2004). The intuitive executive: Understanding and applying 'gut feel' in decision making. *Academy of Management Perspectives, 18*(4), 76–91.

Salas, R. (2015). Managing risks at the early phases of oil and gas major capital projects. In *SPE Health, Safety*. In *Security, Environment, & Social Responsibility Conference-North America* (pp. SPE–173495). SPE.

Salter, A., Ter Wal, A. L., Criscuolo, P., & Alexy, O. (2015). Open for ideation: Individual-level openness and idea generation in R&D. *Journal of Product Innovation Management, 32*(4), 488–504.

Samset, K., & Volden, G. H. (2016). Front-end definition of projects: Ten paradoxes and some reflections regarding project management and project governance. *International journal of project management, 34*(2), 297–313.

Saputelli, L., Black, A., Passalacqua, H., & Barry, K. (2013). Front end loading FEL process supporting optimum field development decision making. SPE Paper 167655. In *Proceedings of SPE Kuwait oil and gas conference*. Richardson, Texas: Society of Petroleum Engineers.

Saputelli, L., Hull, R., & Alfonzo, A. (2008). Front End Loading provides foundation for smarter project execution. *Oil and Gas Financial Journal, 5*(7).

Serrador, P., & Turner, R. (2015). The relationship between project success and project efficiency. *Project Management Journal, 46*(1), 30–39.

Serugga, J., Kagioglou, M., & Tzortzopolous, P. (2020). A utilitarian decision—Making approach for front end design—A systematic literature review. *Buildings, 10*(2), 34.

Shafiee, M., Animah, I., Alkali, B., & Baglee, D. (2019). Decision support methods and applications in the upstream oil and gas sector. *Journal of Petroleum Science and Engineering, 173*, 1173–1186.

Shiferaw, A. T., Klakegg, O. J., & Haavaldsen, T. (2012). Governance of public investment projects in Ethiopia. *Project Management Journal, 43*(4), 52–69.
Shenhar, A. J., Dvir, D., Levy, O., & Maltz, A. C. (2001). Project success: A multidimensional strategic concept. *Long Range Planning, 34*(6), 699–725.
Shore, B. (2008). Systematic biases and culture in project failures. *Project Management Journal, 39*(4), 5–16.
Simon, H. A. (1992). What is an "explanation" of behavior? *Psychological Science, 3*(3), 150–161.
Williams, T.M., Vo, H., Edkins, A., & Samset, K. (2019). *A systematic literature review: The front end of projects - PMI*. Available at: https://www.pmi.org/-/media/pmi/documents/public/pdf/kas/112112_a-systematic-literature-review_r4_final.pdf (Accessed: 19 March 2022).
Smallwood, N. (2020) *Setting up for Success: The importance of front-end loading, Infrastructure and Projects Authority*. Available at: https://ipa.blog.gov.uk/2020/09/09/setting-up-for-success-the-importance-of-front-end-loading/ (Accessed: 19 March 2023).
Smith, P. G., & Reinertsen, D. G. (1998). *Developing products in half the time: New rules, new tools*. New York: Van Nostrand Reinhold.
Smyth, H., Lecoeuvre, L., & Vaesken, P. (2018). Co-creation of value and the project context: Towards application on the case of Hinkley Point C nuclear power station. *International journal of project management, 36*(1), 170–183.
Stanovich, K. (2011). *Rationality and the reflective mind*. New York: Oxford University Press.
Stingl, V., & Geraldi, J. (2021). A research agenda for studying project decision-behaviour through the lenses of simple heuristics. *Technological Forecasting and Social Change, 162*, Article 120367.
Stingl, V., & Geraldi, J. (2017). Errors, lies and misunderstandings: Systematic review on behavioural decision making in projects. *International Journal of Project Management, 35*(2), 121–135.
Svejvig, P., Geraldi, J., & Grex, S. (2019). Accelerating time to impact: Deconstructing practices to achieve project value. *International Journal of Project Management, 37*(5), 784–801.
Taylor, S. J., Bogdan, R., & DeVault, M. (2015). *Introduction to qualitative research methods: A guidebook and resource*. John Wiley & Sons.
Thamhain, H. (2013). Managing risks in complex projects. *Project Management Journal, 44*(2), 20–35.
Turner, R. (2022). Forty years of organizational behaviour research in project management. *International Journal of Project Management, 40*(1), 9–14.
Turner, R. (2021). Emotion regulation during decision making on projects. *Project Leadership and Society, 2*, Article 100035.
Turner, R. (2020). How does governance influence decision making on projects and in project-based organizations? *Project Management Journal, 51*(6), 670–684.
Turner, R. (2014). *Gower handbook of project management* (5thed). Routledge.
Tversky, A., & Kahneman, D. (2004). Judgment under uncertainty: Heuristics and biases. In A. Tversky (Ed.), *Preference, belief, and similarity: Selected writings* (pp. 203–220). Cambridge, MA: MIT Press.
Volden, G. H. (2019). Assessing public projects' value for money: An empirical study of the usefulness of cost–benefit analyses in decision-making. *International Journal of Project Management, 37*(4), 549–564.
Volden, G. H., & Samset, K. (2017). Governance of major public investment projects: Principles and practices in six countries. *Project Management Journal, 48*(3), 90–108.
Wang, Y., & Gibson, E. (2010). A study of pre-project planning and project success using ANNs and regression models. *Automation in Construction, 19*(3), 341–346.
Weick, K. E. (1995). *Sensemaking in organizations*. CA. Sage: Thousand Oaks.
Welde, M., & Odeck, J. (2017). Cost escalations in the front-end of projects–empirical evidence from Norwegian road projects. *Transport Reviews, 37*(5), 612–630.
Williams, T., Klakegg, O. J., Walker, D. H., Andersen, B., & Magnussen, O. M. (2012). Identifying and acting on early warning signs in complex projects. *Project Management Journal, 43*(2), 37–53.
Williams, T. M., Samset, K., & Sunnevåg, K. (2009). *Making essential choices with scant information: Front-end decision-making in major projects*. Basingstoke, UK: Palgrave.
Williams, T., & Samset, K. (2010). Issues in front-end decision making on projects. *Project management journal, 41*(2), 38–49.
Winch, G. M. (2013). Escalation in major projects: Lessons from the channel fixed link. *International Journal of Project Management, 31*(5), 724–734.
Yau, N. J., & Yang, J. B. (2012). Factors causing design schedule delays in turnkey projects in Taiwan: An empirical study of power distribution substation projects. *Project Management Journal, 43*(3), 50–61.
Zsambok, C. E., & Klein, G. (Eds.). (2014). *Naturalistic decision making*. Psychology Press.
Zerjav, V., McArthur, J., & Edkins, A. (2021). The multiplicity of value in the front-end of projects: The case of London transportation infrastructure. *International Journal of Project Management, 39*(5), 507–519.
Yang, M. F., & Lin, Y. (2013). Applying fuzzy multi-objective linear programming to project management decisions with the interactive two-phase method. *Computers & Industrial Engineering, 66*(4), 1061–1069.
Zirger, B. J., & Hartley, J. L. (1994). A conceptual model of product development cycle time. *Journal of Engineering and Technology Management, 11*(3–4), 229–251.