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A SYSTEMATIC LITERATURE REVIEW: THE FRONT END OF PROJECTS

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Executive Summary

This report describes the results of a detailed, comprehensive, systematic literature survey on the front end of a project, commissioned by the Project Management Institute (PMI). It is the result of a collaborative project conducted by academics from University College London, UK, the University of Hull, UK, and the Concept programme based at the Norwegian University of Science and Technology.

The literature on the front end itself has been found to be fairly sparse; although the front end of a project has been shown to be critical to its strategic success or failure, this phase of a project's life cycle is not well understood.

This report presents the literature on the concept of the front end, and defines a temporarily ordered structure of generic processes that form part of the "front end" and how these fit together as a coherent whole (see Figure 2). AQ3
These start from the preliminaries to the initiative, then the project purpose (for various stakeholders), initial analysis and scenario analysis; the analysis of alternatives and choice of project concept; assessment of the project (scope; estimation of cost, benefits, and schedule; risk; technology and sustainability; and the project delivery system), finishing with setting up the project execution (finance, governance, and contracts).

The report then looks at the recent literature on each of these elements in turn, specifically as they relate to the front end of the project, to provide a reference for each of these elements.

This report does not take any specific theoretical stance, but is informed by a clustering of the seven "images," Winter and Szxczepanek (2009) keeping attention on the surrounding environment, the intended project benefits, and the temporariness of the project.

The report finishes with some particular areas where further research would be valuable.

Introduction

This report describes the results of a literature survey on the front end of a project, carried out by University College London, UK; the University of Hull, UK; and the Concept programme based at the Norwegian University of Science and Technology. The work was commissioned by the Project Management Institute.

Morris (2011, p. 6) gives a well-argued case that "data shows that most of the factors which seriously affect . . . project outcome, for good or ill, will have been built-in to the front-end definitional decisions" and describes how the project management profession has neglected this most important area. But he then goes on to state that "the problem is, we don't generically know what managing the front-end really entails". Edkins, Geraldi, Morris, and Smith (2013, p. 71) similarly state that "our understanding of the role of such 'front-end project management' is not well documented in the literature, despite evidence of the importance of the front-end—that many of the things that cause projects not to succeed have their origins in decisions made in the project's front-end and that the front-end is the part of the project that has the greatest opportunity for creating value—and that, despite its importance, 'front-end' management issues, responsibilities, roles and actions are too often ignored by official project management guidance."

While there are a few key references on the front end of projects (see, for example, Edkins et al. [2013], Samset and Volden [2016], Williams and Samset [2010, 2012], Williams, Samset, and Sunnevåg [2009]), there is not a clear definition of the "front end."

Although researchers have, over the years, highlighted the front end of the project as being critical to the strategic success or failure of the project, it is surprising that this crucial stage or, more accurately, phase of the project's life cycle is not better and more clearly understood. In addition, while the above papers are well established in the field, there is not yet a firm theoretical foundation for the topic.

This study reports the findings of a systematic review of publications published primarily between 2006 and 2017 in front-end project literature. The primary aims of this study are to: (1) investigate what defines the "front end" of a project; (2) examine what generic processes form part of the "front end" of a project and how these fit together as a coherent whole; (3) explore whether there are different project management lenses that give different views of the front end; and finally (4) explore what the implications of this work are for the managerial practice.

The report is structured in the following way. In the next section, we summarize the methodology and data used for the systematic literature review. Thereafter follows an overview of the existing research landscape in the front-end stage of projects. The report concludes with a discussion for further research activities in this field, and some managerial implications from this body of research.

Methodology

In order to find out how the front-end notion is used in project management literature, and to see what generic processes form part of the "front end" of a project and how these fit together as a coherent whole, we carried out the search for articles following a four-step procedure. First, we chose the databases and journals where we wanted to conduct the literature search. We then scaled down the time frame within which a paper was published and manually searched within the selected databases, journals, and time frame. In the final step, we picked the most relevant articles which were cited in the publications identified in the earlier activities but were not published in the chosen databases and/or the selected time frame.

In addition to the papers identified through the above process, a number of publications used in this study were suggested based on the experience and expertise of the researchers involved.

We performed the literature search within key academic journals in the period 2006–2017, which allowed for a wide range of recent research to be taken into consideration. We employed the Association of Business Schools' (ABS) Academic Journal Quality Guide (2015), a reputable journal-ranking list in the sector of business and management, for ratings of journals. We focused primarily on mainstream journals such as those in accounting; general management, ethics, and social responsibility; operations and technology management; operations research and management science; public sector and healthcare; regional studies, planning and environment; strategy; journals that explicitly welcome project management; and journals in specific sectors such as regional studies, transportation, etc. Only journals given ratings from three and above were selected for our study, excepting the three following journals which were well known among scholars interested in the field of project management at the time the search was conducted: *International Journal of Managing Projects in Business* (rating 1), *International Journal of Project Management* (rating 2), and *Project Management Journal*® (rating 1).

Besides mainstream journals, a selection of 20 journals in related areas, where the researchers involved have published papers, was added. We believe that restricting the search like this would increase the likelihood of attaining a considerable degree of quality on account of the rigorous peer reviews and expert judgment procedure. However, we did not always employ the list of targeted journals (Appendix A) to refine the search results, particularly in the search for terms that only resulted in a limited or manageable number of publications. It should be noted that not only academic journals were selected for the review but also authoritative official reports and similar publications, as well as "gray" literature and standards that were looked at where applicable.

We searched for publications written in the English language within two major databases in EBSCOhost, including "Academic Search Premier" and "Business Source Premier." EBSCOhost was chosen because it provided access to a broad range of digital resources in extensive and diverse subject areas. Appendix B to this report demonstrates the list of keywords that we employed for the literature search. Where necessary, the search terms were paired with appropriate terms to make sure the search was restricted to the exact information we looked for. We divided the search terms into two groups: the primary and the exploratory. The primary group includes the central term "front end" and similar words. The exploratory group comprises terms which relate to the term "front end" to a certain extent. The search was proceeded through three steps to make the review of papers more manageable: In Stage 1, we only searched for the publications using the primary set of keywords; in Stage 2, we synthesised the outcome of Stage 1 and then conducted a second search using the set of exploratory keywords where appropriate; and finally, we identified key papers from the above two stages, and (1) used citation indices to search systematically for good papers that cite these, and (2) looked for any particular key references used.

Publications were retrieved based on the following screening techniques:

- We only searched for items within the field of either "All Text," "Abstract," or "Subject Terms;"
- We only refined the search result using the set of targeted journals where the search result was large or unmanageable; and
- We left out articles that were outside the area of interest or whose theoretical underpinnings were unclear (e.g., by examining the article names and looking at keywords and abstracts).

We believe these techniques helped us locate high-quality publications in the areas most relevant to our study. This search created a total data set of 43,164 papers. In spite of the rigorous search rules and techniques, many of the retrieved papers appeared to be less relevant or irrelevant. After a preliminary analysis of the publications, we were able to eliminate 42,799 papers, which resulted in a final data set of 367 papers for further and more detailed analysis. The selected publications covered a wide range of topics relating to the project front end.

A summary of the results of the literature search is given in Appendix B. Together with 155 references which were: (1) suggested by researchers involved, and (2) cited in the 367 papers identified but are not published in the databases and/or within the chosen time frame, the total number of papers considered for this study summed to 524 papers.

In the subsequent section, we will present an overview of the existing research landscape in the front-end stage of projects.

Theoretical Lenses

This report does not take any specific theoretical stance; rather, it is informed by the various theoretical lenses taken by the literature, many summed up in the overview given by Turner, Huemann, Anbari, and Bredillet (2010). For the purpose of this review, a relatively simpler summary of some of the theoretical lenses is given by Winter and Szxczepanek (2009), whose work was suggested by PMI in commissioning this work. Winter and Szxczepanek provide seven theoretical "images," and the use of these images or lenses has indeed given three important motivations for our discussion.

- *The surrounding environment* – "Image 1: Projects as social processes:" The front end needs to be anchored in the surrounding environment, so Section 2 is at the start of the logic of this report, moving quickly to a consideration of the stakeholders (and indeed, the wider world in Section 6.5). But "Image 1: Projects as social processes" looks at the reality of projects as a stream of activity, which influences the governance of the project set up in Sections 6.6 and 7. "Image 2: Projects as political processes" picks up the different agendas affecting projects giving the same starting point as (i), but adding at the start the decision biases of stakeholders (Section 2.4) and the various agendas and strategic aims throughout Section 3. This lens also reminds us to consider strategic misrepresentation and optimism bias when assessing projects (Sections 6.2.6–6.2.7). This embedding of the project within the motivations of the permanent organization and other stakeholders is an important theme of the report.
- *The intended benefits* – "Image 3: Projects as intervention processes;" "Image 4: Projects as value creation processes;" and "Image 7: Projects as change processes" keep our attention on the intended outcomes of the intervention rather than simply delivering the outputs of the defined project. This is particularly discussed in Section 3.2 as we define what is actually required from the project. "Image 5: Projects as development processes" continues this theme but reminds us that projects are not one-off and separate, so our statements about "a front end" to "a project" should not be taken too simplistically. This emphasis on outcomes and desired changes rather than project deliverables is important throughout this report.
- *Temporariness* – "Image 6: Projects as temporary organizations" has been one of the important trends in thinking about projects over the past two decades, and this forms a fundamental underlying theoretical lens for this report particularly as we take the completion of the front end as (simplistically) the start-up of the temporary organization. But we take issue with this title, and think through these issues in detail at the start of our discussion (Section 1.1).

1. The Front End

1.1 What Is the Front End?

The definition of the "front end" of the project is bound up with the definition of what a "project" is. Morris discusses this at length in his "Reflections" (2016), drawing a distinction between those that see this as the vital "shaping" part of a project, and those that see the project only starting once the "front end" is completed. Edkins and Smith (2012, p. 138) consider this further, noting that there is not agreement, but do conclude that there is consensus (and evidence) that "the early stages of a project are one of the primary points where strategic success or failure for the project is set". Here, we do not need to decide on this argument: It is agreed that the front end exists, and is necessary and important.

A project results when an organization or party has a desire to achieve a particular change or outcome. When this desire is sufficiently specified and formalized, a person or organization is delegated to undertake a defined project, whose output is deemed appropriate to achieving or contributing to that change or outcome. The organization that initiates the project and desires the project outcome is often called the "permanent organization," although, as will be seen in later sections of this report (Section 1.3), the terminology varies as we encounter those who are "sponsors," "owners," and "clients."

This is in contrast to the extensive literature around the phrase the "temporary organization" (Packendorff, 1995) for the entity that undertakes the project. Often the project can be undertaken by an entirely separate organization from the permanent organization. For the type of project studied by Merrow (2011, p. 126), "the contractor's job is to deliver a project as specified, on time, and on budget. The owner's job is to specify the right project". However, there is no necessity for there to be a separate organization. Indeed, early work on matrix organizations assumed team structures superimposed upon the permanent organization structure (Wilemon & Cicero, 1970). The Project Management Institute (2013) defines a project as "a temporary endeavor undertaken to create a unique product, service, or result." However, this does not imply the existence of a separate organization or indeed the existence of an organizational structure (although it is difficult to imagine executing a project of any size without some sort of organizing). Bakker's (2010) review of organizing talks about "temporary organizational forms" rather than temporary organizations. (Note that we here, therefore, disagree with Bannerman's proposed definition, which considers a project as necessarily "a temporary organization to which resources are assigned . . . " (2008, p. 7).

The important element here is the permanent organization and its definition of its needs. The nature of the organization or structure undertaking the project is actually a decision to be made in the front end of the project. The essential element here is that the undertaking or project is temporary—or more properly "determinate" (i.e., it has a foreseeable and pre-agreed delivery objective and end time) as defined by Winch (2014). Winch (2014) says that it has seemingly become "axiomatic" that project organizing is temporary, but challenges this "axiom," and immediately cites the PMI definition as a statement of this axiom—although the definition does not mention the word "organizing," making this perhaps a tangental example.

The review of the "front end" of the project will thus engage with the period from the earliest thoughts and discussions up until the permanent organization tasks the person or organization who is to be responsible for delivering the project (as shown in Figure 1). It makes no assumption of the nature of that person or organization—and indeed, one of the tasks of the "front end" will be to start to explore that nature.

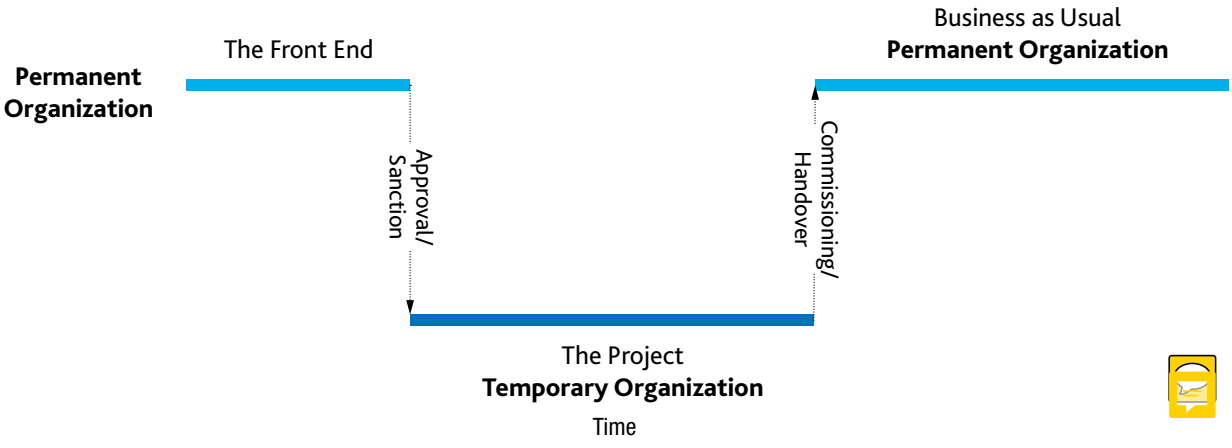

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Figure 1. Project's front end: The relationship between the permanent and temporary organization.

This is, of course, recognized as being somewhat simplistic. In particular, there will often be a pre-contract or mobilization phase between a contract being granted and the start of that contract. We deem this to be outside of the "front end" since a contract is defined and placed at this point (and besides, there appears to be little literature in this area). Furthermore, the concept of the single "front end" within the permanent organization might well consist of subgroups that shape and define the project—but this is all within the permanent organization, and therefore considered within the front end.

The strategic role of the "front end" is in shaping project "success" (where we should define success in terms of strategic performance, rather than, as is often the case, simply tactical project performance [Samset & Volden, 2016]). This brings in the need for recognizing the "drivers" for what may become the project: opportunities (achieving something desirous) and problems (resolving something that is harming or troubling). The two key words or concepts that result are:

- Strategy
- Context

These two concepts are clearly heavily interrelated. An important message for those considering the front end is to understand that the project "emerges" from some form of consideration. This can be actively encouraged or unexpectedly apparent. Whether active or passive, all projects are the result of some form of consideration and [sanction]ing process.

This then brings in the two vitally important components of the front end: the principal players and the primary process. "Ideation" is at the heart of the latter. The Oxford English Dictionary defines "ideation" as "the formation of ideas or mental images of things not present to the senses; the creation of new ideas." Before artificial intelligence does away with the need for human creativity, ideation is an innately humanistic ability—and it can be very random through to highly structured. This refers to both the project level (Kock, Heising, & Gemünden, 2016) and portfolio level (Kock, Heising, & Gemünden, 2015).

The key players can be considered as the "who" and in asking "who is driving the project?" One has to then ask "and why?" The "who" drives the front end: It is from the organization that has a desire to achieve a particular change or outcome. That organization will have to put in place project governance to oversee the project, but this is distinct from project management. Samset and Volden (2016) define project governance as the processes, systems, and regulations that the financing party must have in place to ensure project success, and

note that often fewer resources are used up front to identify the best conceptual solution and structure (project governance), than to improve tactical performance during implementation (project management).

The "who" is thus most typically from outside the project management function. It may be that project management (as a function) is in some way involved, but it is clear that it is not a core area of project management. While much of the understanding of what goes on in the front end is still unclear and poorly understood, what is clear is that it is project management's role to deliver the (initially undefined) project. In those cases where the proposal for the project does come from within the project management fraternity, the question of motivation becomes important as the evidence is recognized that the "rush to solution" may be that there is no problem, but rather it is some party's (say the project manager) interest to propose a new project as in so doing the project manager function achieves something—such as survival, respect, or political or resource power. Section 1.2 discusses fully the roles involved in the front end of the project.

As discussed above, we have not formally defined here the point at which the front end finishes. Generally, it is considered to be the point at which there is a final sanction to authorize the project. This can, however, sometimes be not clear and/or well defined. It is the point at which responsibility is handed over to the individuals with, ideally, accountability and responsibility for delivering the defined and approved project. What is striking in this discussion is the variety of ways that the front end can be considered and understood—although it could be suggested that the greater the maturity of the permanent organization in dealing with projects, the more structured and well defined the management of the front end is likely to be.

This discussion also points to what is, perhaps, a gap in knowledge. Previously there has been much work on two areas: first what organizations need to do and why, for example considering digital and societal transformation in the economic geography. This area is well-grounded but treats projects as entities that realize strategy.

Second, the internal study within well-defined projects. This literature comprises traditionally very theory-light normative studies, although this has developed in recent years.

The front end is where these two come together: The project does not sit alone, but within an environment and context which defines the need and context for the project. The move recently into "project studies" (e.g., Geraldi & Söderlund, 2018) recognizes the need to study them both together and the complex interfaces between them (recognizing environment and politics).

What Happens in the Front End?

With the importance of the front end being increasingly recognized by practitioners, policymakers, and scholars, it is no surprise that there is increasing interest and indeed demand for the necessary tools to manage the front end and for clear structures that allow the determination of accountability and responsibility for both the progression and performance of the front end. The tools that are being looked at deal with issues associated with the uncertainty, fuzziness, and ambiguity that the front end necessarily involves. The seeking of clarity and focus drives much of this, and whether it is from deploying computational techniques, social science methodologies, or human experience and tacit knowledge, the quest is to help those who are involved in the front end to reveal, articulate, and structure the data, information, knowledge, and wisdom that are potentially there to be captured and used. The range and scale of the challenge for both recognizing what lies within the front end and how it is to be managed and progressed reflects the diversity in scale and nature of the universe of projects. It is trite to assume that there is a "one-size-fits-all" solution, especially when objectives and goals for projects can vary among those instigating the project.

It is clear from the literature that a number of activities or events occur during the front end, and this gives the structure for this document. The front end is where the following happens:

1. *The initial idea emerges*. Where does the idea for the project come from, what is it based on, whose interests would it serve, and who would pay for it? This is discussed at length in Sections 2–3.
2. *Complexity and underlying problems and needs ought to be analyzed*, as discussed for example in Samset (2010), or the Australian Transport Assessment and Planning (ATAP) Steering Committee (2016a), which describes the Australian procedures for early planning of transport projects. Building on Section 3.4, these aspects are considered further in Sections 4.1 and 4.2. As discussed above, these need to be contextualized: Stretton (2016) looks at project context management, the variables that influence project contexts, how these relate to a basic project life cycle, and how important they are in the early project initiation phases.
3. *The first estimates of costs and benefits are made*. Early estimates are important to evaluate the project (Section 4.4), although these will become refined as a project concept is identified. These issues will be covered in (ix) below.
4. *The stakeholders' preferences and incentives become visible*. This is discussed particularly in Section 3.3. It can be complex, and Winter's work (e.g., 2006) considers the front end of projects, where objectives are often unclear and where different constituencies have conflicting aims, and suggests a role for problem-structuring methods to help define preferences and incentives. Stakeholders can be in complex structures, and Aaltonen and Kujala (2010) explain how a better understanding of secondary stakeholders influences behavior during the project life cycle and enables the use of more effective project stakeholder management approaches. Lack of attention here can have significant effects; for example, public investments with no financial obligations for the target group may cause perverse incentives and result in counterproductive projects (Samset & Volden, 2016).
5. *There is very little information* (see Section 4.1.2). The front end is characterized by scant information available about the prospective (as yet ill-defined) project (Williams et al., 2009). The danger here is that decisions are based on an overload of detailed information (which will be uncertain) up front rather than carefully selected facts and judgmental information relevant to highlight the essential issues (Samset & Volden, 2016).
6. *Uncertainty is at its highest*. Section 4.1 describes how this uncertainty can be navigated, and how possible scenarios of the future need to be considered. At this stage, before the project is defined, the use of highly refined and applied "heavyweight" project risk management (Section 6.2.8) is not yet possible. Olsson and Magnussen (2007) illustrate and quantify the freedom to maneuver in different project phases, based on some empirical data.
7. *The opportunity space is/should be explored*. Section 5 discusses this exploration, which clearly ought to be systematic. Samset and Volden (2016) discuss the frequency with which the choice of conceptual solution is made without systematically scrutinizing the opportunity space up front. This issue partly explains the well-noted "rush to solution."
8. *The conceptual alternatives are carved out*. This is discussed in Section 5. Lessard and Miller (2013), discussing the shaping of large engineering projects, note that the seeds of success or failure are planted early. A key to successful projects lies in the choice of concept (Samset & Volden, 2016).
9. *First estimates are refined*. First estimates are refined as the concept is developed, and estimates are fully discussed in Section 6. The focus is often on the final cost estimate (the budget), while early cost estimates are overlooked (Samset & Volden, 2016). Kloppenborg, Tesch, and Manolis (2011) explain the importance of trending the cost estimate during the project development or front-end engineering design.

Consideration of optimism bias (Section 6.2.5) and strategic misrepresentation (Section 6.2.6) is important, and an important technique that will be discussed in Section 6.2.7 is reference class forecasting, a method to approach these (see e.g., Flyvbjerg, Chi-keung, & Wing Huen, 2016).

10. *Recognizing stakeholders*. The affected parties could/should have a chance to have some impact on decisions. Section 3.2 discusses stakeholder engagement. This is a source of sometimes vital feedback, often forgotten, and illustrates the nonlinearity of the process.
11. *The situated project*. The project should be regarded/integrated within a wider strategy/project portfolio. This need to consider the project within the context of the organization's portfolio is discussed in Section 3.1. Kock et al. (2016) consider how important this is, and investigate how and under which circumstances the performance of the front end affects project portfolio success.
12. *The foundation is laid and the main decisions are made*. These are discussed in Sections 5–7.
13. *"Quality at entry" can be secured*. In other words, the project can have high-quality definition due to the work of Sections 3–7, and confidence can be placed in its success (see further discussion in Section 1.2).

This list of issues and factors not only gives the structure for this document, but it illustrates the process and logic through which a project front end proceeds (as presented below in Figure 2), although noting the comment in (x) above that there can be feedback and nonlinearities in the process.

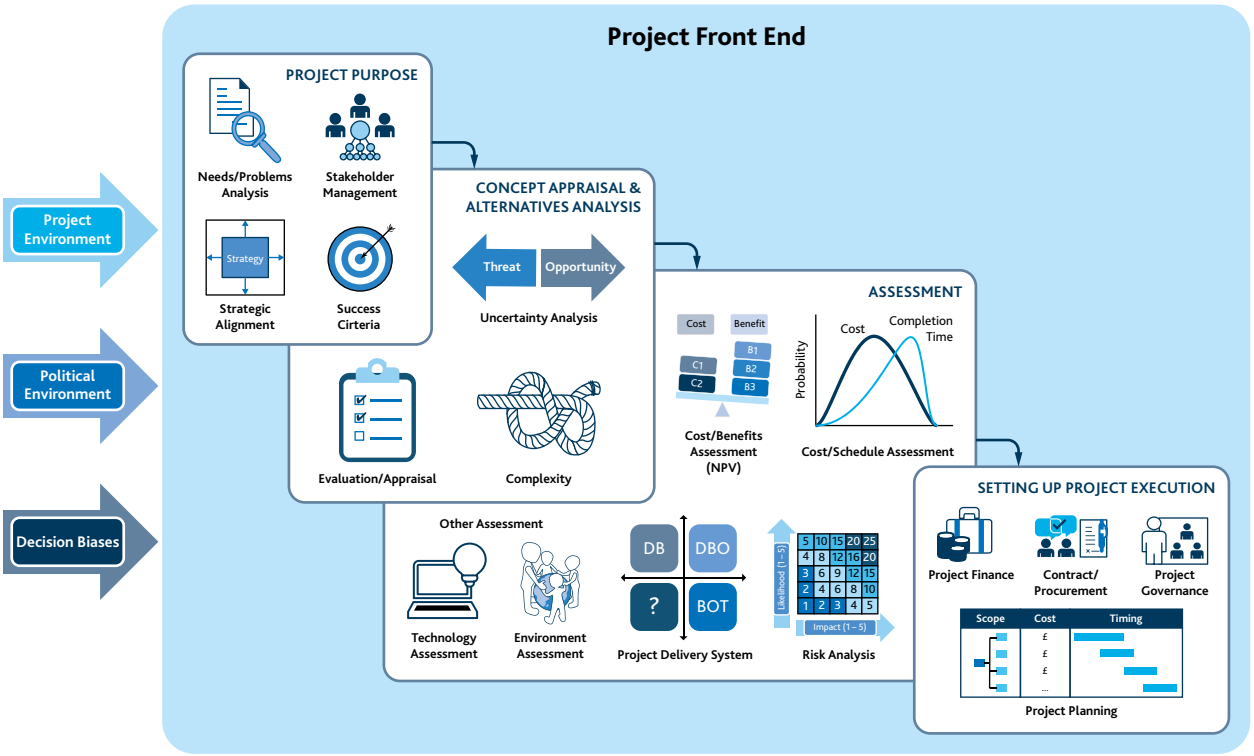

Figure 2. Summary of the front end. Note that this diagram is partially based on Samset's overview of how techniques for concept appraisal fit together (Samset, 2010, p. 161, Figure 16.1). The diagram was designed to illustrate the front-end process rather than the roles in the front-end phase. Roles will be considered separately in Section 1.3.

1.1.1 The Importance of the Front End

The importance of the front-end, decision-making phase in securing projects' long-term success is being increasingly recognized (Samset & Volden, 2016). Flyvbjerg (2013) says that the front end is the most important stage in the project life cycle in securing project success. The interest in the front end as a discrete part of the management of the project (noting that we technically are managing a phase that is before the project formally exists) is justified from the downstream results. The literature seems to be clear that an emphasis on a careful and thorough front end is related to project success (e.g., Shiferaw, Klakegg, & Haavaldsen, 2012).

The importance of the front end is particularly because critical decisions are made during this phase, which suggests that more effort should be invested (Kock et al., 2015). For example, in new product and process development, almost 80% of the product and industrial process are specified in the early phases (Jankovic, Cardinal, & Bocquet, 2009). Morris writes that "'the project front-end,' which, it is generally now accepted, is probably the single most important area of management focus in the management of projects" (2016, p. 366). In the literature found in this study, for example, Heising (2012) discusses how at the front end of projects, opportunities are discovered, ideas are created, and the foundation for later project, portfolio, and, eventually, corporate success is laid.

Barshop and Harries-Rees (2003) claim that front-end loading is the practice that has the greatest impact on project outcomes, particularly because improving project definition reduces the number of execution-phase changes. Papers such as Kock et al. (2016), Kock et al. (2015), Hwang and Ho (2011), Anderson and Merna (2003), and Cravens (2017) all confirm a strong positive relationship between front-end success and project or portfolio success. Faniran, Love, and Smith (2000) suggest that front-end project management is particularly important in developing countries.

Kock et al. (2016) demonstrate empirical evidence of a strong, positive relationship between front-end success and project portfolio success. Similarly, Meier (2008) gives empirical evidence suggesting that early pre-acquisition activities executed in a rigorous fashion can significantly reduce the risk of cost and schedule growth. Collins, Parrish, and Gibson (2017) use statistical analysis to show that projects with better scope definition had significantly improved cost and schedule performance than projects with lesser scope definition, and argues that front-end planning is potentially the most impactful activity in the management of construction projects. Thomas and Ellis (2007) indicate that better pre-bid plans will reduce costs, shorten schedules, and improve labor productivity. Flore and Chase (2005) show that front-end control during the design phase lowers the risk of cost overrun and scope creep. Similarly, Hollmann (2002) claims that "past improvements in average cost growth were largely driven by improved up-front project definition prior to full authorization of project funds (i.e., front-end loading)."

In contrast, Williams, Klakegg, Walker, Andersen, and Magnussen (2012) suggest that "roots of problems in later project phases are found in processes and decisions at the front-end of projects." McClory, Read, and Labib (2017) give the top reason for project failure according to practicing project managers as poor pre-planning for the project (including "lack of ability to manage the front-end very well"). Eun Ho, Naderpajouh, Hastak, and Gokhale (2016) show that inadequate construction input at the predesign stage and during the front-end planning results in fragility of plans in terms of constructability. For public-private partnerships, which will be separated out a number of times in this document, Raisbeck and Tang (2013) show that design development through the effective management of an initial design is a critical factor. Lindstrom (1993) considers inadequate system engineering during front end as one of five pitfalls to destroy a development project. Even where the "front end" is not mentioned as such, Stretton (2014), for example, found 42 different causes for project failure, many of which could be grouped as project initiation (unclear success criteria, changing sponsor strategy,

funding difficulties, poor project definition, unrealistic project baselines, incomplete requirements, inadequate estimating, unrealistic expectations, commitment escalation, etc.).

A key advantage of this front-end phase is the clarity with which the fundamental reasons for the project can be addressed, before the confusion between achieving "project delivery" success and "project outcome" success (see Section 3.2). In this stage, because the business case focuses on the benefits the customer or user hopes to receive, then this can form the basis of the planning documents (Kloppenborg, Tesch, & Manolis, 2014). As an example of the clarity arising from this phase, Kwak, Walewski, Sleeper, and Sadatsafavi show five factors for the successful completion of the Hoover Dam, the first being "project development activities including feasibility study, site selection, and conceptual design essential for satisfying legislative requirements as a result of which project mission, scope, and challenges were clear for all the parties involved with the project and helped them overcome project issues" (2014, p. 263).

Where the front end is not given sufficient resources (including money, time, and degree of intellectual focus), then the front end is rushed and pressure of progressing the "project life cycle" is to put a project on a list—this list effectively being the portfolio. Rushing projects onto such a register or into a portfolio gives the project credibility. This then provides the opportunity to place pressure for both continuing existence and resource attention. The literature appears clear that this acceleration through the front end to the point of sanction legitimization is recognized as a cause of downstream failure. Wearne (2014) suggests that poor front-end management leads to "fire-fighting execution." Such is the concern of the consequences of such failure that in certain areas (such as industrial, oil and gas, and extractive sectors), the emphasis on the front end (Front-End Loading [FEL], Front-End Engineering Design [FEED]) is there to force the minimization of the chances of later problems. This emphasis, therefore, logically drives the need for contingent thinking and action.

1.1.2 Front-End Maturity – Knowledge Transfer

Early estimates of a project's efficiency, effectiveness, and impacts are undoubtedly challenging, and therefore it is important to acquire experiential knowledge by studying similar projects (Samset, 2013). While projects are by definition "new," a more mature organization will be able to transfer knowledge about projects and how to develop a front end. Lê and Bronn (2007) show how to link experiences gained in the operation and maintenance phases of one project to the earlier construction phases in subsequent projects, and offer a model to show the economic benefits.

Chronéer and Backlund (2015) aim to help this process by developing an "organizational-wide project learning process" to improve learning in project-based organizations. They argue that some type of "process-thinking" supporting learning and experience feedback should be integrated with the "project-thinking" in project management, and that such a process view should be valid not just to support learning at the closure of projects but between different project phases, thus again linking the closure of projects to the front end of subsequent projects. Indeed, learning should come from the cumulative project experience prior to a new front end. Williams (2016), for example, encourages the move from learning from a project portfolio (in this case, to learn about the organizational, cultural, and environmental factors that can lead to success or failure in a program of projects).

There are also specific areas in which learning clearly should be used. One is estimation, which is discussed in Section 6.2. But the article "Bank Ups Pre-Project Corruption Screening" (Construction Europe, 2015) suggests there is little attenuation over time of optimism bias in capital cost estimation, appearing to reflect an absence of learning on the part of those making the estimates. Lyngsø Møller, Horsager, and Tambo (2016) discuss the influence of knowledge sharing in managing project portfolios in professional services, showing the need for continuously collecting knowledge about pending and ongoing projects to perform project selection and resource allocation.

1.2 Front-End Stage Gates and Bidding for Funding

Part of the object of the front end in some contexts is to prepare a project for funding approval or sanction and some version of a stage gate review. There are a variety of stage gate systems in place; Klakegg, Williams, Magnussen, and Glasspool (2008) give a full discussion of the system in the public sector in a number of countries; in looking at the front end of major construction projects in Ethiopia, Shiferaw, Klakegg, and Haavaldsen (2012) note the problems caused by the lack of mandatory control gateways. In the private sector, Roobaert (2011) describes the use of FEED stage gate processes to provide a degree of assurance for upper management; Jambhekar and Weeks (2008) also give an example of FEED.

Strang (2011) looks at stage gates in portfolio selection and evaluation. Caron, Fumagalli, and Rigamonti (2007) discuss the use of risk analysis support bid/no-bid decision-making processes looking at the overall project portfolio, suggesting that insufficient time is spent in this phase, leading to project risk assessments that are unstructured and highly subjective or even completely overlooked.

This ought to be the stage at which the best project is crafted or designed, but one of the paradoxes identified in practice by Samset and Volden (2016) is that "less resources are used up front to identify the best conceptual solution, than to improve tactical performance during implementation." But it might be that this sort of mechanism is becoming more frequent: "Bank Ups Pre-Project Corruption Screening" (Construction Europe, 2015) shows that in 2014 the number of pre-project due diligence reviews that the Asian Development Bank (ADB) carried out was up 73%, compared to 2013.

1.3 Roles in the Front-End Phase of Projects

The front end needs to be governed properly, and for that, there are different types of roles that need to be filled. This section tries to differentiate these roles. There are, in fact, no agreed definitions of such roles, although there is a paper that does attempt to bring such common definitions—"Who's Who in the Project Zoo? The Ten Core Project Roles" (Zwikael & Meredith, 2018). However, this section will separate and focus upon the main roles within the front end.

The importance of governance within the project itself and the filling and separation of these roles will be discussed further in Section 7.2. But in particular, Miller and Hobbs (2005) discuss governance regimes for large capital projects and outline the challenges of designing such regimes. They identify a number of themes that most affect the front end of megaprojects and then explore the life cycle relationship between projects, institutional frameworks, and contextual environments. Matinheikki, Artto, Peltokorpi, and Rajala (2016) similarly look at governance within inter-organizational networks, and Aaltonen, Kujala, Havela, and Savage (2015) examine the stakeholder dynamics during the project front-end stage of two large pioneering projects.

Again, clarity is needed in distinguishing between the front end, embedded in the permanent organization, and the project environment being set up in the front end. This means that there are quite different roles in these two different project phases. As an example, Sewchurran and Barron (2008) explore the role played by the project sponsor and project manager in successfully delivering IT projects: The paper finds a fundamental lack of understanding and appreciation of each other's environments; project sponsors are rooted in an operational environment, and project managers in a project environment. Because of this lack of understanding and appreciation, communication barriers exist. In order to overcome these barriers, it is found that both project managers and project sponsors need to engage in an ongoing dialectic relationship to understand and appreciate each other's respective environments. The front end of the project is the start of such dialectic relationships between all the different roles and moving into the project phase.

It is clearly useful to distinguish what the roles and responsibilities are for the various parties. This is important in the front end, but it is also important to define these roles and responsibilities within the front end for the latter execution phase of the project, particularly distinguishing the two essential parties defined in Section 1.1: the "permanent organization" interested in the strategic benefits which are outcomes from the project, and the project delivery team tasked with producing the project deliverables which are considered to be the means to the end of the strategic benefits. Elbarkouky and Fayek (2011) look at this distinction linguistically, helping to define roles and responsibilities and considering fundamental problems of conflicts, duplication, and gaps in roles and responsibilities.

While the Zwikael and Meredith (2018) paper referenced above found 10 project roles, we use a coarser classification, and find in the literature five types of roles.

(1) Owner

The owner is the organization or person who ultimately derives the strategic benefits from the project. This organization was highlighted in Section 1.1, which stated, "the important element is the permanent organization and its definition of its needs." It is thus at the heart of the initiation of the front end of the project in actually having the need that is to be satisfied by the project, and is critical in assessing the "success" of the project as it is those benefits or needs that will be considered when looking at the outcomes of the project. Winch and Leiringer (2016), for example, look at transportation infrastructure projects and focus on the contribution of the "strong owner" to project performance, giving the basis for a research agenda on the role of the owner in such projects in achieving high performance.

Where the "owner" is an organization, there are clearly different roles within that organization, particularly in the early stages. Edkins et al. (2013) show that the chief financial officer (CFO) plays a critical role in the progression of the front end. The question of "ownership" at this early stage is nebulous and variable. As the organization is in that vague and uncertain intellectual/organizational space where a problem or opportunity may trigger the need for a sanctioned project (or it may not), there are many internal players pitching and responding; the CFO (similar to a finance ministry or treasury) holds the purse and keeps control of it. Then within the C-suite, dispute can arise as the chief executive officer, carrying hierarchical and board power, comes up against the chief technology officer, holding technological power, and the CFO, holding financial power. This seems to be a rich area and more study is needed here (see Section 8).

(2) Sponsor

Still remaining at the level of the permanent organization, and still looking at the strategic benefits of the project (rather than the immediate project deliverables, determined only when the project is defined, which are simply the means to the end), it is considered best practice to have one individual responsible for the delivery of the strategic benefits. This individual we can call the "sponsor." (In the UK public sector, this is could be seen as the role known as the "senior responsible owner" [Stephens, Assirati, & Simcock, 2009]).

Kloppenborg, Tesch, Manolis, and Heitkamp, for example, identify the executive with the "fiscal authority, political clout, and personal commitment to see a project through" (2006, p. 16), and define that person as the project sponsor. This paper examines and classifies behaviors associated with this role and looks at the relationship with various aspects of project success. Crawford et al. (2008) continue with this theme, providing evidence to demonstrate that success or failure of projects is not simply down to the project

delivery organization (i.e., the project manager and project team), but identify the "sponsor" as key in: linking corporate and project governance, ensuring that governance requirements are met, and providing support to projects and programs. Again, this paper tries to identify the characteristics of effective performance of the sponsor role. Similarly (and thirdly in time of publication), Kloppenborg et al. (2011) look at behaviors sponsors may use during project planning and the impact such behaviors have on project success measures, particularly for projects where there are multiple stakeholders with differing views and success criteria.

The distinction between "owner" and "sponsor" is confused a little by Zwikael, Smyrk, and Meredith (2016), who propose the role of a "project owner" as key in the governance of the project. For this paper, the project owner is responsible for attaining the strategic benefits sought by what they call the "funder" (or the "project client"), and the authors give a project governance model and 10 research hypotheses; this "owner" here is what we are calling "project sponsor."

(3) Project manager

Perhaps the role with the greatest clarity is that of "project manager," tasked with delivering the outputs of a specified project. In the front end, the project itself is not yet defined and approved, so a project manager cannot be given the responsibility. It could be argued that there is no need for any project manager in the front end, since the granting of responsibility to the project manager to deliver the project outputs almost by definition marks the end of the front end and the start of the project. In *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* – Sixth Edition (Project Management Institute, 2017) this would be marked by the specification of a "project charter." However, project managers often generically play an advisory role in the front end, using their expertise to help define a feasible, achievable project. Indeed, Cardenas, Voordijk and Dewulf propose a project governance model for infrastructure projects which includes the involvement of the contractor in what might be considered the "front end," contributing to the "design and estimation of costs, procurement procedures, integration of design and construction, the incentives and disincentives regime, risk allocation [and] contract flexibility" (2017, p. 432). Such a view leads to the consideration of "early contractor involvement," which is widely referenced in terms of the construction sector (see, for example, Mosey, 2009).

(4) Communities and the public

While communities and the public might take no formal role in the front end or delivery of a project, in any major (particularly public) project, they will be stakeholders (see Section 3.2), so their role needs to be considered as part of the front end. Edkins et al. (2013) look at the different phases of a project during its life cycle, and consider how secondary stakeholders' behaviors change during that life cycle. This enables a set of propositions to be posed about the potential of secondary stakeholders to influence the project management's decision making. A particular method used by Canning and Holmes (2006) is the repertory grid technique: In a very public area of projects (developing new museum projects and exhibition), respondents were able to list both perceived and practical barriers to participation in projects.

(5) Users/beneficiaries

A final important area of stakeholders is those people who will directly use or benefit from the project. This might be a subset of (iv), and can sometimes be subsumed into this set. However, direct users or direct beneficiaries will have specific inputs that can be valuable not only to the detailed design of a project but even to considering the project concept (Section 5).

1.4 Specific Issues

1.4.1 Megaprojects

Two specific comments are made before the main argument. The first is that megaprojects have particular aspects that make the front end both important and more difficult. The second concerns innovation and will be addressed subsequently.

Megaprojects are large-scale, complex projects delivered through various partnerships between public and private organizations (van Marrewijk, Clegg, Pitsis, & Veenswijk, 2008) with certain characteristics such as public investment, high ambitions, multifaceted product arising from complex decision-making processes, multiple actors, and multiple impacts (Priemus & van Wee, 2013). They have very long initiation and delivery phases delivering capital assets that are used for decades or centuries (Brookes, Sage, Dainty, Locatelli, & Whyte, 2017). These projects involve multiple temporalities in delivery, product life cycle, stakeholder organizations, and special purpose vehicles, combining more and less temporary forms of organizing in the process of enactment.

Based on these characteristics, Flyvbjerg (2014) explains why and how megaprojects are systematically subject to "survival of the unfit:" "The data show that for too many projects with front-end problems . . . creativity never materializes and projects end up seriously impaired or non-viable." Having said this, van Marrewijk et al. (2008) note the same problems but consider them under the titles of uncertainty, ambiguity, and risk. From this it is derived that different project designs and project cultures can guide managers and project partners in how to cooperate to achieve more successful project objectives. Locatelli, Invernizzi, and Brookes (2017) also point to success factors.

Being in the public arena, "success" generally includes significant social responsibilities for megaprojects (Ma, Zeng, Lin, Chen, & Shi, 2017; Zhou & Mi, 2017); the socio-cultural context of all of the stakeholders needs to be understood (Eling & Herstatt, 2017); interface analysis and management is particularly important (Shokri, Ahn, Lee, Haas, & Haas, 2016); public sentiment is important (Hanchen, Peng, & Maoshan, 2016); and there is an important need for a public engagement process (Leung, Yu, & Chan, 2014). One example of projects that are clearly highly dependent on the social implications and dialogue with stakeholders would be decommissioning projects (Christensen, 2011). Dyer (2017) explores the implementation of megaprojects and their risk associated with social responsibilities through the lens of cultural sensemaking, suggesting that what is needed is an understanding of the socio-cultural context of stakeholders through sensemaking. O'Leary (2012) extends this line of development and offers an index to cover the social responsibility of megaprojects.

The prolonged life cycle and heterogeneous stakeholders of megaprojects pose significant challenges for the governance of the economic, social, and environmental issues involved (Ma et al., 2017; Samset, 2011); governance needs to be particularly flexible for megaprojects to deal with emergent complexity, and willing to change as the project development process unfolds (Miller & Hobbs, 2005). Customers and other stakeholders actively engage in the value-creation process (Chang, Chih, Chew, & Pisarski, 2013). And within the project, appropriate information feed is essential to ensure the project is aligned with what the project manager perceives to be senior management's view of the project's drivers (Eweje, Turner, & Müller, 2012). Corruption also needs particular attention in megaprojects (Locatelli, Mariani, Sainati, & Greco, 2017).

Uncertainty is at a high level in megaprojects. Sanchez-Cazorla, Alfalla-Luque, and Isabel Irimia-Dieguez (2016) give a literature review of risk management in megaprojects and classify risks into nine categories (see Section 6.2.8). Megaprojects are also complex (e.g., Chapman, 2016). We have to understand the implications of risk and complexity for governance. Cardenas et al. (2017) suggest variables for measuring project governance

in construction projects in uncertain environments, and Sanderson (2012) looks at different explanations for the performance problems in megaprojects, and suggests some fundamentally different governance mechanisms.

1.4.2 Innovation Within Projects

The second comment is that, for major infrastructure projects, which are long-term capital investments, "Innovation, as it relates to the physical, process, organizational/contractual, and financial/revenue dimensions of a project, has a central role to play in not only contributing to the requirements set for a wide variety of project performance metrics but also improving upon them," say Tawiah and Russell (2008), who provide tools to assess project innovation potential at the front end.

According to Rogers (1983, as cited in van Binsbergen, Konings, Tavasszy, & van Duin, 2013), every innovation goes through an innovation development procedure covering five phases: knowledge (a new solution to a problem is identified and explored), persuasion (the favorable and unfavorable attitudes toward the innovation are analyzed), decision (deciding on whether or not to adopt the innovation), implementation (the innovation is developed and tested), and confirmation (evaluation of the decision that was taken to foster the innovation). Van Binsbergen et al. (2013) consider quality and complexity of an innovation (i.e., the relative advantage, compatibility, complexity, and testability) and the process and social context in which an innovation should materialize (including the composition and diversity of stakeholders, characteristics of competitors, and the role of the government) are important factors facilitating a successful implementation of an innovation.

Davies, MacAulay, DeBarro, and Thurston (2014) identify four stages of opportunity to interfere to produce, ascertain, and implement innovation in a megaprojects: (1) the bridging stage during the front end when knowledge from other projects and industries are utilized to formulate an innovative project process and governance structure; (2) the engaging stage, when tendering and contractual procedures can be employed by the client to support contractors and suppliers to promote novel notions and solutions; (3) the leveraging stage, when all the parties involved are gathered to create innovative ideas to enhance performance; and (4) the exchanging stage at the back end, when ideas and resources for innovation can be (re)joined with those of other projects in the broader innovation ecosystem to enhance performance.

The Crossrail megaproject in London, UK has been the focus of innovation with a strategy for this (Worsnop, Miraglia, & Davies, 2016), which specifically set out to foster innovation in an open and transparent way. (See also Davies, Gann, & Douglas, 2009, on Heathrow Terminal 5.)

2. The Initiative: The Preliminaries

As we consider the genesis of a project, we need to look at the environment when it emerges, and how a proposed project is developed, as well as some fundamental ideas necessary before we move onto the genesis of the project itself.

2.1 Environment

2.1.1 Project Environment

A project does not exist in isolation but is often subject to different internal and external factors that can support or hinder its successful completion. External factors surrounding a project's environment comprise "all relevant aspects of public affairs, economics, and the social scene" (Gilbert, 1983, p. 84) within which the project must operate. All these forces are complex, uncertain, and can affect a project's outcome and hence need to be well understood before a project is undertaken. The analysis of the project environment, if done well, will facilitate the project to carefully position itself to its environment and align its objectives and management techniques with the existing situation and context (Artto, Kujala, Dietrich, & Martinsuo, 2008).

2.1.2 Political Environment

Within the public domain, Christensen (2012) describes major public projects as a political and administrative decision-making process in which politicians utilize a neutral administrative mechanism to execute the policies adopted by the elected legislative bodies. The political environment thus impacts the project indirectly through the strategic context of the organization created by the decisions made by the top management level (Narayanan & DeFillippi, 2012).

In recent years there has been growing interest in the political aspect of projects. A literature survey conducted by Söderlund (2011) has categorized articles on project management into seven schools of thought; among them is "Decision School," characterized by its primary interest in explaining the complexity of the political and decision-making processes inherent in public projects during their early phases.

Studies on the project front end, such as those discussed in Williams and Samset (2010, p. 46), point out that the formation of project strategy and significant decisions during the front end of major public projects are usually not made solely by individuals, but in consideration of "social geography and politics" of decision-making groups. The authors also indicate the opposing effects of political biases, preferences, and pressures on the estimation of project costs and benefits. These findings are reinforced by the study conducted by Samset and Volden (2016, p. 7), who say that "decisions are made at the intersection between the professional and political" during the project front end, and that legislative priorities might have more significant impacts than rational judgment on the decision making. The authors support the use of external quality assurance to ensure a genuine and democratic decision-making process and reduce negative impacts of "political bargaining" during the front end of major public investment.

However, the evidence on the influence of political forces on the decision-making process during the front end of a public project is not all clear. For example, Christensen's (2012) study of the 23 major public projects in Norway shows no sound impression on the holistic and robust control of political executives. In addition, the research indicates that: (1) projects at the local and regional level have a smoother collaboration between

politicians and expert authorities than those at the central government level; and (2) central government has a stronger influence on the national projects than on the local and regional projects.

2.2 Business Case/Project Proposal

Numerous scholars have recognized the importance of a well-written and thoroughly researched business case during the early phases of the project life cycle (e.g., Dalcher, 2011; Hoppszallern, 2010; Merrow, 2011). Some governmental bodies such as the HM Treasury (Flanagan & Nicholls, 2007) and professional bodies such as the Project Management Institute (2013a) consider the business case to be an essential part of project management and a "must-have" for any project or program. However, many organizations are reluctant to assert that their projects are "approved on the basis of a well-founded business case linking the benefits of the project to explicit organization goals (whether financial or not)" (Cooke-Davies, 2005, p. 2).

A variety of definitions of the term "business case" have been offered by academics and project management organizations (e.g., see Association of Project Management, 2012; AXELOS, 2009; HM Treasury, 2013; Kopmann, Kock, Killen, & Gemunden, 2015; Maritato, 2012; Project Management Institute, 2013a, 2013b, p. 3). Key aspects of these definitions are summarized as follows:

- It is a written document capturing the justification for the initiation of a project, both in terms of quantitative and qualitative.
- It is prepared during the early stages of prospective projects as a basis for the decision on the feasibility of the project and to inform the go or no-go decision.
- It can range from voluminous, comprehensive, and well structured to brief and informal.
- It evaluates cost, benefits, timescales, and uncertainty of a range of options or the option of doing nothing, and provides a rationale for the most preferable choice.
- It establishes baselines against which the project progress and success can be measured.
- It is a living document to reflect the constant change of the project environment.
- It is initiated by the executive or manager above the project level (maybe with the assistance of the project manager) and managed throughout the project life cycle by the project manager.
- Motives for the creation of the business case include market demand, organizational need, customer request, technological advance, legal requirements, ecological impacts, or social need (Project Management Institute, 2013a).
- Periodic review of the business case should be held at key decision points to confirm the enduring validity of justification.
- For major projects, the business case might be developed through three key stages, including the "Strategic Outline Case," the "Outline Business Case," and the "Full Business Case" (HM Treasury, 2013, p. 9).

As discussed above, the literature supports the view that it is not the responsibility of the project manager to develop the business case. So far, we have only found one case that takes a converse view (see Association of Project Management, 2012). On the subject of public investments, the UK government has advised its departments to not allocate the accountability for the creation of the business case to external consultants, although external consultants might assist when there is a lack of necessary skills and expertise from the in-house resources (HM Treasury, 2013). All elements of a business case will be explained in detail in later sections of this study.

There are some terms that are occasionally confused with "business case". Such terms include project charter, project proposal, project initiation document, and project plan, but these all have clear distinctions. In particular,

and for our purposes, at the initial stage of defining an idea, it is not clear what the project will be, and an initial business case will be developed to justify developing a project. While there is a general lack of literature distinguishing between the "business case" and the "project proposal," the former initially defines the business case for some sort of initiative; the latter is a much more relaxed term and could represent a proposal to do an as-yet-undefined project or to undertake a project that is at least partially defined. Or it can be used to refer to a document that is prepared as a response to a request for tender or a request for funding application. Furthermore, there is generally a view that there is generally no need to keep a "project proposal" up to date throughout the project life cycle, unlike the business case, which should be routinely reviewed and, when necessary, revised.

Samset and Volden (2012) highlight the need for the development of the project proposal (i.e., starting from an idea through to developing the definition of the project) in advance of the conclusion of the pre-study stage, when the selection of alternative concepts is still allowed. The authors consider the project proposal as a basis upon which an initial decision of a go or no-go option could be made with further examination of alternatives.

In the UK, the "Five Case Model" is recommended by the Office of Government Commerce as a standard for the development of business cases and is extensively used within central government departments and their agencies (HM Treasury, 2013). The model looks to establish a case for investment by examining the five key areas: strategic case, economic case, commercial case, financial case, and management case (HM Treasury, 2013). The model starts with the preparation of strategic outline programs, through to the creation of strategic outline cases, outline business cases, and ultimately, full business cases (HM Treasury, 2013).

For projects where procurement is involved, a request for proposals from suppliers and contractors and the evaluation of proposals are essential milestones notwithstanding of the development of methodologies that are employed (Ben-David, Gelbard, & Milstein, 2012). The analysis of these proposals formed a critical part of the procurement business case (HM Treasury, 2013).

Few scholars have addressed the use of the business case at a project portfolio level (Kopmann et al., 2015). The study led by Kopmann et al. (2015) has demonstrated a positive relationship between "business case control" and the success of project portfolio, and how responsibility for the realization of the business case and relating incentive schemes might extend this positive outcome. The authors identify three main elements constituting business case control, including: (1) the evaluation and prioritization of project proposals using the business case; (2) the ongoing monitoring of the feasibility of evolving projects; and (3) the tracking of the business case regarding benefits realization following the project closure.

2.3 Project Selection and Go/No-Go Decisions

Every project starts with a proposal, but not all proposals can lead to a project. In this way, project selection becomes one of the most important factors in the success of any change project or program (Kumar, Antony, & Rae Cho, 2009), especially where limited time/human resources and funds are two main issues that commonly face projects.

It is generally accepted that the decision process that follows a sound logical reasoning and chronological order should ultimately result in the selection of the best project. However, Williams and Samset (2010) point out that the selection process, in reality, is "complex, less structured, and affected by chance," and is often influenced by biased or insufficient analysis as well as political priorities.

Various methods for project selection have been offered in the literature (Puthamont & Charoenngam, 2007), of which each method has different features and characteristics and is best when it is customized for different organizations. The study by Liesiö, Mild, and Salo (2007) on the practical uses of project selection methods suggests that clear and simple methods that take into consideration multiple criteria tend to result in better decisions and have better chances of being accepted by decision makers. The systematic literature review conducted by Dutra, Ribeiro, and de Carvalho (2014) results in 35 different criteria used in project selection methods, which are classified into four groups: strategic benefits, business benefits, technical difficulty, and financial costs.

There is a large volume of published studies highlighting organizations' tendencies to incorporate various methods to meet the necessities that assure success in project selection. For example, the study of Cooper, Edgett, and Kleinschmidt (2001) demonstrates that financial methods are most widely used and will result in better outcomes when they are used in conjunction with other methods. Dutra et al. (2014), drawing on an extensive range of sources, propose a selection model in which the use of economic and probabilistic approaches are integrated in order to quantify the investments and their potential uncertainties to decision makers. Wei and Chang (2011) combine the use of a multi-criteria, group decision-making method and fuzzy set theory to assist R&D managers in the selection of new project development (NPD) project portfolios. This model takes project performance, delivery, and risk under consideration, and articulates the selection process of NPD project portfolios as a "fuzzy linear programming" issue.

The approach taken to project selection is not universal and depends upon the sector being considered. Major oil companies often employ a three-stage, front-end process for the initiation of projects, which includes "appraise," "select," and "define" stages (Jambhekar & Weeks, 2008). If in the "appraise" stage the business case is validated and justified, the "select" stage is where the project concept is chosen. There are two steps involved in the "select" stage. The first is about evaluating options and eventually picking the best option; the second step focuses on the conceptual design for the chosen option. The outcome of this stage is the production of a completed concept which is then further defined to a level of detail needed. The recommended concept will be subjected to further analysis to make sure it still aligns with the organization's strategic objectives. Academic methods for carrying this out include Amiri (2010) who developed a new method for the selection of oil-field development, which employs the six criteria as used in the Analytic Hierarchy Process (AHP) technique developed by Saaty and the fuzzy Technique for Order Preference by Similarity to Ideal Situation (TOPSIS) developed by Yoon (1987) and Hwang, Lai, and Liu (1993). AHP is used to understand the structure of issues related to project selection and to decide criteria weighs, and the fuzzy TOPSIS method is applied to achieve the final ranking.

On Information System projects, a study by Hsu, Liang, Wu, Klein, and Jiang (2011) found that the performance of this type of project can be improved by considering the user perspective in the screening criteria of the project selection process.

For the selection and prioritization of projects in transporting, manufacturing, and service industries, where the consideration of equity issues in resources distribution is necessary, a method developed by Joshi and Lambert can be adopted. The method is based on a combination of "network-level equity metrics along with traditional metrics in formulating a generic multi-objective combinatorial optimization (MOCO) problem and visualizing multi-objective trade-offs on the spatial network" (2007, p. 539).

For construction projects, Han, Kim, and Hyoungkwan propose a profit prediction model for the selection of international projects, including "defining, analyzing, and evaluating various profit-influencing risk variables" (2007, p. 354).

In the case of a project using the traditional design-bid-build delivery method, the selection of supplier or contractors is a critical factor. Ben-David et al. (2012) proposed a methodology for bid evaluation, which assumes each bid can be composed of several prospects/alternatives. Their preliminary attempt was to help the client to compare and appraise "multi-alternative proposals" from suppliers and contractors, and to select not only the best proposal, but more essentially to identify the suppliers and contractors who offer the most appealing set of alternatives for different circumstances which may happen throughout the life cycle of a project.

Puthamont and Charoenngam (2007) propose the use of three phases (i.e., conceptual phase, design phase, and final approval phase) for selecting projects for the purpose of budget allocation in public sector. For major public projects in the UK, the Five-Case Model (HM Treasury, 2013) suggests the use of Strategic Options Framework and Strengths, Weaknesses, Opportunities, Threats analysis for the identification and selection of the best short list of options from the long list; the best option from the "short list," including "doing nothing" or "doing minimum" options, will then be selected and subjected to the outcome of the detailed cost-benefit analysis (Puthamont & Charoenngam, 2007, p. 44).

Cost-benefit analysis is commonly thought of as a useful technique to support the project selection process. However, a recent study by Samset and Volden (2016) reaches a moderately different conclusion, finding a lack of confidence from decision makers in Norway in the analysis, although a significant amount of resources are often allocated to conduct detailed analysis upfront. The authors gave a number of explanations for such low faith; for instance, the weaknesses in the methodology, strategic use of the analyses to stimulate a preferred outcome, and the difficulty in quantifying some costs and benefits of investment. More detail on the use of cost-benefit analysis during the project front end will be discussed in Section 6.2.

2.3.1 Where Projects Come From – The Planned and the Urgent

All of the material presented so far assumes that a project has come out of planned consideration within an organization. There are different circumstances where a project is driven by extreme contexts such as emergency
AQ8 contexts, risky contexts, and disrupted contexts (Hällgren et al., 2018).

The most obvious class of project that is undertaken with the least planning is the response to emergency situations and disasters. Here, the project is provoked by an "incident." These can be man-made such as a riot, act of terrorism, political controversy, or a natural disaster such as an earthquake, avalanche, volcanic eruption, or tsunami. Whatever the cause, the incident triggers the needs for a response, which can be seen as a portfolio of separate projects or a coordinated program.

While there is relatively scant literature on this area through the project lens (Yan, Suzanne, Regan, & Erica, 2012), there is a more diverse literature on disasters and disaster recovery when considered more generically (Phillips, 2015) or when considered as a process (Quarantelli, 1999). As the specific variations in such urgent and important projects cannot be completely predicted, the focus is on the planning and preparedness of those responding. It is therefore not surprising that the focus is on the topics of learning from emergency
AQ8 contexts (Hällgren et al., 2018), availability and management of resources (Yan et al., 2012), and capability (Sheth, McHugh, & Jones, 2008).

A new genre of urgent projects is emerging as the result of the immediacy of the internet and the proliferation of digital media. This is an area of project activity that is not yet well understood, but it is clear that whether used as a means of marketing as in the rise of digital guerrilla marketing (Levinson, 2007) or in an anti-establishment
AQ5 context (Juris, 2005), the rise of the *digital natives* presents a new opportunity for rapid and emergent projects.

2.4 Decision Biases

Decision making is an integral part of any project and program. During the project front end, decision making plays a crucial role in ensuring the right project is selected for execution or further planning. In an ideal world, any decisions are assumed to be made based on rational and logical judgment (see, for example, rational choice theory). However, as pointed out by Miller and Hobbs (2009, as cited in Williams & Samset, 2010), the underlying assumptions of rational decision-making systems are usually impractical in the situations of a real project. A number of issues often cloud the judgment and lead to choices that do not align with an organization's strategic objectives.

Nobel laureate Herbert Simon, who is perhaps best known for the theory of bounded rationality, supports the idea that humans are only partially rational (as cited in Kalantari, 2010). He argues that humans are limited in integrating and processing all the information that would be needed to make a rational decision; in other words, the human mind is bounded by cognitive limits (Simon, 1982). Therefore, decision makers (i.e., senior managers), in many circumstances, accept choices which are only satisfactory (Isenberg, 1991).

Cognitive biases are natural to humans and particularly affect project decision making. Many different types of decision biases have been reported in the literature. For example:

- Xu, Chen, Wong, and Cheng (2015) suggest the existence of selection bias in build-operate-transfer transportation project appraisals. Selection bias in this case refers to a phenomenon in which only winning projects will be built and observed, and where losing projects are never created or never appear in the system, which might cause overestimation.
- The study carried out by Moret and Einstein (2012a) discusses decision biases in probability estimation.
- Kirkebøen explains causalities of some common systematic biases and proposes solutions to correct them; such biases are divided into six main classes: "biases in information processing," "preference reversals and biases associated with the presentation of data," "motivated reasoning," "confirmation bias," "overconfidence bias," and "hindsight bias" (2009, pp. 178-183).
- Flyvbjerg (2009, as cited in Williams & Samset, 2010) divides biases into three categories, including technical bias (i.e., bias caused by an honest mistake or the shortage of forecast techniques), psychological bias (i.e., "optimism bias"), and political-economic bias (i.e., explanations to the deliberative claim of an optimistic view of the future).
- A study conducted by Liedtka (2015, p. 932) identifies nine cognitive biases which are sorted into three groups. The first groups of biases "relate to decision-makers' inability to see beyond themselves and escape their own pasts (projection bias), current state (hot/cold gap), personal preferences (egocentric empathy gap), and tendency to be unduly influenced by specific factors (focusing illusion)". The second group is about "the inability of their users or customers to articulate future needs and provide accurate feedback on new ideas [. . .] (say/do gap)." And finally, the third group of biases links to "flaws in decision-makers' ability to test the hypotheses they have developed. They are unimaginative (availability bias), overly optimistic (planning fallacy), and wedded to initial (endowment effect) and preferred (hypothesis confirmation bias) solutions."

Significant research has focused on explaining the overconfidence or optimism bias. These are biases in human behavior that might lead decision makers to underestimate costs and overestimate benefits (Lovallo & Kahneman, 2003). Much academic evidence of these stems from the Nobel-prize-winning work of Kahneman and Tversky (1977, 1979) on a systematic fallacy in decision making under uncertainty, which Lovallo and Kahneman (2003) later refer to as the "planning fallacy." Such biases often prevent people from carrying

out even simple analysis prior to making decisions (Virine, Trumper, & Virine, 2012). The study conducted by Haji-Kazemi, Andersen, and Klakegg considers optimism bias of project managers and the lack of outside views as some of the barriers to the ability to detect the early warning signs of a project. The paper expanded "Ansoff's management model by clarifying the mentality filter in order to better define the procedure whereby obstructions are created" (2015, p. 1068).

Often overlooked by the literature is the bias in which the way that organizations structure their remuneration systems leads decision makers to become reluctant to bear uncertainty even when there is clear evidence that the potential losses of a project are much less than its potential earnings (Koller, Lovallo, & Williams, 2012). Such behavior is referred to as "pessimism bias" in this study. Koller et al. (2012) consider the risk appetite, specifically risk aversion, of decision makers as a primary cause of the phenomenon, and encourage the use of an "organization-wide" guide toward risk to reduce the effects of risk aversion.

There has been an extensive amount of literature on approaches and techniques to mitigate the impact of cognitive biases (Prater, Kirytopoulos, & Ma, 2017). An example of this is the study carried out by Flyvbjerg (2013) in which the use of the eight-step procedure for quality control and due diligence, which is based on the "outside view theory" of Kahneman and Tversky, is introduced to encounter the effects of optimism bias. Ben Mahmoud-Jouini, Midler, and Silberzahn (2016) suggest the use of "design thinking" to help organize thoughts during the explorative phase of projects, whereas Zerjav, Hartmann, and Achammer (2013) and Macmillan, Steele, Kirby, Spence, and Austin (2002) encourage ways of thinking informed by reflective practice to help the design process. Interestingly, research has strongly supported the idea that a combination of different methods tends to deliver the best results (Boehm, Abts, & Chulani, 2000; Prater et al., 2017). Further details on the evolvement of optimism bias in front-end estimates are discussed in Section 6.2.5.

3. Project Purpose

Why have a project at all? We have said that a project has its genesis in an organization, and this is where we start.

3.1 Connection With Strategy

Every organization could be considered as having its own "personality," usually determined by its strategy, which typically comprises "its mission, objectives, strategic direction and tactics" (Camilleri, 2016, Chapter 4). Projects are increasingly perceived as powerful strategic weapons of organizations and thus every project has to start with the organizational strategy (Williams & Samset, 2010). Strategy affects how project management is oriented in a company (Milosevic & Srivannaboon, 2006; Srivannaboon & Milosevic, 2006), and "serves both as a bridge that connects internal operations and the external environment, and as an absorber of the environmental uncertainty for the conduct of projects" (Narayanan & DeFillippi, 2012, p. 16).

It is a fundamental principle in management that the goals of any project must be lined up with organizational strategy in order to maximize the organization's resources and potential performance. *A Guide to the Project Management Body of Knowledge (PMBOK® Guide)* (PMI, 2013a) supports this belief by indicating that "projects are often utilized as a means of directly or indirectly achieving objectives within an organization's strategic plan" (p. 9). Morgan, Malek, and Levitt (2008) describe executing the strategic process by means of projects in a six-step process: (1) establishing the organization's purpose/long-term intentions; (2) translating intentions into strategies, goals, and metrics; (3) aligning strategy with the company's culture; (4) "do the right projects required to carry out your strategy" (portfolio management); (5) "execute the projects in the right way;" and (6) transition the results of the projects into the organization's operations.

Although projects are a means of implementing the organizational strategy, few studies seem to have investigated or recognized the linkage between the shaping and executing of projects and the implementation of the organizational strategy (Morris, 2009).

Samset and Volden (2016, p. 304) define the alignment of objectives as an essential activity that needs to be carried out before commencing any significant work on a project. In this exercise, the underlying logical structure outlining the project is determined by "following the causal link" throughout the project life cycle, starting from the problem that accentuates an intervention, the fundamental requirements of users and society, through well-defined objectives, to the delivery of project outputs, outcome, and eventually, the realization of long-term benefits after the project's closure. Only once the project objectives and requirements have been appropriately determined can effective planning occur (Sutterfield, Friday-Stroud, & Shivers-Blackwell, 2006). However, this is not always appropriately done (Cooke-Davies, 2009) as "projects are complex, ambiguous, confusing phenomena" (Linehan & Kavanagh, 2006, p. 6) in which the idea of a sole and entirely explicit goal is just an unrealistic dream (Engwall, 2002).

Most of the activities of connecting the project purpose with the organizational strategy take place during the front end of projects, which Cooke-Davies (2009, p. 106) calls "front-end alignment of projects." However, too often, inadequate time is spent in the early phases of a project to establish a robust project definition, which Morris (2009, p. 45) names the old "rush to code danger." Samset and Volden (2016, p. 305) point to "a need for a more concise formulation of objectives" and a statement of scope in the front-end phases of projects to

form a common understanding of the project's direction and when a target is achieved. Numerous studies have attempted to investigate ways to help projects overcome all the challenges facing front-end alignment. For example, Cooke-Davies (2009) suggests using a well-established business case and the accomplished execution of a well-formulated engagement program. Rudzinski and Uerz (2012) develop techniques to generate strategic insights on innovation. Joham, Metcalfe, and Sastrowardoyo (2009) use problem-structuring methods to help conceptualize the problem.

Fit

Cooke-Davies, Crawford, and Lechler (2009) show that the "fit" between an organization's strategic drivers of value and the configuration of its project management system determines the value it obtains from project management. Strategic fit has been considered as an important aspect of organizational structuring driving the front-end phase that can result in better project performance during project implementation (Rauniar & Rawski, 2012). Similar results showing the importance of the fit between project management implementation and the strategy of the organization are given in Thomas and Mullaly (2008).

Project Strategy

Patanakul and Shenhar (2012) reported a growing trend of "strategic project management" in the literature, in which the general idea is that the project team focuses on not only achieving the traditional iron triangle (i.e., time, cost, and scope), but also supporting the business strategy and sustainability of their company. The authors highlight the need for the concept of project strategy to be well understood and defined to enable the project team to select the correct strategy at the initiation of the project as well as make it compatible to the business strategy. However, the authors found a lack of a generally accepted definition of project strategy and thus tried to fill this gap by providing an explicit description. According to Patanakul and Shenhar, project strategy can be defined as "the project perspective, position, and guidelines for what to do and how to do it, to achieve the highest competitive advantage and the best value from the project" (2012, p. 7).

It is often thought that aligning with corporate strategy means projects have to follow the strategy of their parent organization. However, this is not always the case. For a project to stay aligned with organization's strategy, Samset and Volden indicate a need to identify the project's environmental turbulence and enhance the capability to deal with this confusion during the initiating phase of the project; in other words, "flexibility needs to be built into the project strategy, both in the front-end concept stage, and at later stages" (2012, p. 56). Their view reinforces Artto et al. (2008), who suggest the opportunity for projects to play a more proactive role in the formulation and implementation of the corporate strategy; put differently, projects do not always need to adopt a role of "obedient servant." Following this line of thought, Vuori, Artto, and Sallinen (2012) enlighten how the magnitudes of the relationship between the parent organization and the project affect the development of a project's strategy which may deviate from the expected strategy of the parent. They suggest that the strategy of a project is somewhat autonomous of that of its parent organization. This autonomy is subjected to a degree of relatedness between the project and the parent organization (i.e., the lower the level of relatedness, the more autonomy they require).

One question that needs to be asked is who should be responsible for bringing project objectives into line with the organization's strategy? Previous research into this, however, has been inconsistent and contradictory. For example, according to Sutterfield et al. (2006), that should be the responsibility of top management. Their idea contrasts with that of Christenson and Walker (cited in Sewchurran & Barron, 2008), who believe the project manager is responsible for the development, communication, and maintaining of the organization's vision.

In practice, the precise sharing of responsibility varies from organization to organization and often depends on the characteristics and desires of the individuals filling these roles (Morris, 2009). Shaker (2014) proposes a centralized role of a chief innovation officer in the permanent organization to drive innovation practice, and has the ideation and implementation processes. Rauniar, Doll, Rawski, and Hong, based on the analysis of the data collected from 191 new product development (NPD) projects from the U.S. automotive industry, demonstrate the role of "heavyweight product managers" in both the cross-functional team and project performance, through assiduously affecting the extent of "strategic alignment, shared project mission, and clarity of project targets" in the earliest stages of projects (2008, p. 130).

3.1.1 Portfolio

The majority of studies that investigate the front end consider it as a single project management task rather than a project portfolio management mission (Heising, 2012). Project portfolio management serves as a bridge between organizational strategy and project management (Tharp, 2007). It focuses on selecting and prioritizing the most suitable projects and programs to support the strategy of the organization, and dismissing ones that no longer contribute to the organization's business success (Too & Weaver, 2014). Narayanan and DeFillippi (2012) define the project portfolio of an organization as a reflection of its underlying corporate strategy; in that way, the project management journey of an organization is typically started through the impromptu formation of independent projects following requests from senior management.

According to Kock et al., front-end success is an essential determinant for the success of a project portfolio, of which real benefits rely upon a large number of "potential contingency factors" (2016, p. 118). Sanchez and Robert (2010) demonstrate how a project fits into a portfolio satisfying the strategy. An Analytic Network Process is used by García-Melón, Poveda-Bautista, and Del Valle (2015) to optimize the alignment of the project portfolio with corporate strategic objectives. It is important to note that the project portfolio depends not only on strategy, but needs the organizational structure to align with the criteria within the portfolio project-selection system (Kaiser, El Arbi, & Ahlemann, 2015). One idea is the Mission Breakdown Structure (Andersen, 2014), mimicking the work breakdown structure to understand the mission of the project in relation to the mission of the organization. Stakeholders, in this case customers, need to be considered in an integrated fashion across the portfolio (Voss, 2012; Voss & Kock, 2013). Lyngsø Møller et al. (2016) emphasize the importance of knowledge management in the management of the project portfolio during the front end.

One challenge is to decide what to fund or guarantee in a portfolio. Wibowo and Kochendoerfer (2011) employ a mathematical framework for the selection of Indonesian build-operate-transfer/public-private-partnership infrastructure. When choosing within the portfolio, the movement of technology and where decisions have irreversible implications needs to be considered (Focacci, 2017). Tharp (2007) suggests the integration of a balanced scorecard into the project management so that an organization can directly tie its strategy with tactical execution by translating "a high-level strategic plan into operational plans" and incorporating a "feedback loop" in its strategic planning procedure. Strang developed a new portfolio selection model, also called the "weighted normalized portfolio selection and evaluation method" (WNPSEM), based on the existing theory of analytical hierarchy process (2011, p. 88). The model can: (1) objectively validate and utilize varied expert sentiments; (2) normalize any type or scale of qualitative and quantitative factors (3) shift the responsibility for risk-calculation to bidders; and (4) directly compare all the scores, which are in "relative dimensionless units" (p. 91). Kopmann et al. (2015) recognize a lack of research considering the use of business cases at a project portfolio level to maximize the value generated by project investments. Based on the analysis of a cross-industry sample of 183 firms, the authors confirm a positive relationship between "business case control" and "project portfolio success."

There also seems to be a general lack of research in the concept of an innovation portfolio and its link to the organizational strategy. Mathews (2010) differentiates between "innovation portfolio" and "project portfolio," in which a project portfolio is concentrated on managing products in development and led by a clearly defined strategy, whereas an innovation portfolio is designed to manage ideas from an initial concept to the front end of a project portfolio, and loosely constructed around an evolving strategy. The front end of innovation is acknowledged as a vital driver for the success of NPD projects. Although organizations must produce an adequate number of high-quality ideas and concepts to achieve a well-balanced portfolio of potentially fruitful projects, only the best and most suitable ideas and concepts are selected due to resource and capability constraints. Kock et al. (2015, p. 541) introduce the concept of "ideation portfolio management," which is defined as managerial practices that facilitate "the generation and selection of valuable and relevant ideas and concepts for the transfer into the innovation project portfolio." The authors emphasise the significance of balancing all the elements of ideation portfolio management (i.e., "ideation strategy, process formalization, and creative encouragement") to achieve successful front-end and project portfolio management. A systematic portfolio management approach is also suggested for the integration of ideation and project portfolio management, which ensures that only suitable ideas and concepts are selected and facilitated (Heising, 2012).

3.1.2 Program Management

It is also worth noting that the strategy connection exists not only via the project portfolio level, but also through the program level. For example, Rijke et al. (2014) talk about the strategic focus of program management, which positively contributes to the performance of the program as a whole. However, here we are accepting that, particularly in government projects, the words "project" and "program" are concepts that are muddled together. The work we describe here applies to both self-standing projects and to programs.

3.2 Success Criteria

Central to the definition of a project is what we mean by the project "succeeding."

Success criteria and success factors are the two components of project success (Müller & Turner, 2007). These are very different ideas and need to be distinguished. How a project is defined to be a success—success criteria—must be clearly stated up front at the concept phase to ensure the future success of a project ("Many Shades of Success," 2015), even though this stage encounters significantly scant information and high uncertainty. This section will look at how to define project success and what it means.

What influences project success—success factors—are more contested, and clearly are not meaningful until project success itself has been defined. Management of front-end definition (including project success criteria) can strongly influence whether a project will succeed or fail (Morris, 1998). While some literature is included below on this area, the primary requirement at this point is to define success criteria.

As pointed out by Ika (2009), project success is an "ambiguous, inclusive, and multidimensional concept." There is no absolute definition of project success that applies to all projects in all environments (Albert, Balve, & Spang, 2017; van Niekerk & Steyn, 2011). Likewise, there are no specific patterns for the selection of success criteria across different fields of application (Albert et al., 2017). The definition of project success is dependent on one's perception and personal objectives (Agarwal & Rathod, 2006; Koops, Bosch-Rekveldt, Coman, Hertogh, & Bakker, 2016; Müller & Turner, 2007; Samset & Volden, 2012; Turner & Zolin, 2012) and varied by project types (Cserháti & Szabó, 2014; Müller & Turner, 2007), stages of the project life cycle (Do Ba & Tun Lin, 2008; Turner & Zolin, 2012), and nationalities (Müller & Turner, 2007). The study by Węgrzyn (2016) has revealed

that public and private parties do not share a common perception of project success; compared to private sector organizations, their public counterparts are more exposed to external factors, and thus external factors play a more crucial role in the success of public projects.

While a variety of definitions of the term *project success criteria* have been suggested, this study will use the general definition proposed by Müller and Turner (2007) who saw them as the measures by which the successful outcome of a project will be judged. Due to the multifaceted nature of project success, of which only some criteria are clearly quantifiable (Williams, 2016), it is typically not simple and straightforward to measure success in projects (Samset & Volden, 2012). Traditionally, project management has focused on delivering the planned outputs based on the iron triangle of schedule, budget, and quality, in which quality is defined as "the consistent conformance to customer expectations" (Basu, 2014). However, these indications have been seen to be insufficient as measures of project success (Kerzner, 2006, as cited in Cserháti & Szabó, 2014; Samset, 2003). The literature survey conducted by Albert et al. (2017) illustrates this point clearly by showing that this triumvirate of objectives are increasingly not the only elements for the determination of project success. Koops and colleagues (2016) discovered four separate perspectives on project success (the conventional project manager, the product-driven manager, the parent-driven manager, and the manager with a focus on stakeholders). They found that although the iron triangle is identified as important by all public project managers, in none of the perspectives were the three criteria of the iron triangle ranked in the top three.

The critical point here is to appreciate that we are in the process of project definition—ahead of formal sanction. Initially, we have needs that we (and other stakeholders) require to have satisfied. Success is therefore defined as the satisfaction of those needs. This can be described as project *outcome* success or project *benefit* success. Once a project is defined, then it will have particular targets, including schedule and cost: Satisfying these will give *delivery* or *operational* or *efficiency* success. This is where the iron triangle fits. There is often confusion between these two types of project success, and we need to establish longer-term values that a project can contribute to the fulfillment of corporate objectives (Greenhalgh, Macfarlane, Barton-Sweeney, & Woodard, 2012; Williams & Samset, 2010). The study conducted by Chan, Scott, and Lam (2002) is an early example extending the definition of project success criteria beyond the iron triangle, and this is complemented by the work of Cooke-Davies (2004).

Perhaps the most influential framework classifying the strategic success criteria was developed through work with the U.S. Agency for International Development, then the United Nations and OECD (Samset, 2010, Chapter 2). This characterizes a project's success by five criteria, the first of which (only) reflects the operational iron triangle element:

1. Efficiency (Could the outputs have been produced in a better way? Was the project well managed?)
2. Effectiveness (Were the goals achieved? Did the output meet the goals?)
3. Relevance (How useful was the project to the organization in context? Was the goal aligned with the needs of the organization?)
4. Impact (Was the goal appropriate to the purpose of the organization? What was the sum of the anticipated/unintended effects of the project?)
5. Sustainability (Will the positive impacts of the project continue longer term?)

Examples of these ideas are given by Williams (2016, p. 99): "A project such as the Sydney Opera House or the Scottish Parliament, famously over-budget and late, but producing iconic buildings, might be considered unsuccessful in efficiency but effective. Samset's (2009) Norwegian offshore torpedo battery (on time and

on budget, but closed down by Parliament a week after opening) could be described as successful in efficiency terms, but unsuccessful in impact, relevance, and sustainability. Similarly, a project such as the Three Gorges Dam appears successful in terms of efficiency, effectiveness, and relevance, but has been the subject of considerable debate in terms of impact."

Project success includes different criteria which are independent but come together in complex, causal interactions (Williams, 2016). Key to these are the higher-level success criteria set up before the project is defined and is therefore relevant to the front end, then the efficiency measures ("iron triangle") to deliver the subsequently defined project. Literature in this area has seen the suggestion of many criteria, and we list these here:

- The controllability of the procedure between the project front end up to project delivery and closure; the project fits for purpose and satisfies explicit "political or social factors" within the given budget; and the balance between stakeholder needs and explicit "political or social factors" (Koops et al., 2016).
- The realization of organizational strategic objectives (Ika, 2009; Patanakul & Shenhar, 2012).
- Meeting the project's specified objectives (Cserháti & Szabó, 2014).
- Customer satisfaction and other stakeholder satisfaction (Blaskovics, 2016; Williams, Ashill, Naumann, & Jackson, 2015).
- "Efficiency, impact on the customer, business and direct success, and preparing for the future" (Shenhar et al., 2001, as cited in Patanakul & Shenhar, 2012, p. 9).
- The triple bottom line, which are the economic, social, and environmental criteria (Ghanbaripour, Langston, & Yousefi, 2017).
- Flexibility, which is the project's ability to deal with changes in the project definition or scope and compensate them with slight impacts on schedule, budget, and quality by implementing appropriate management policies and actions (Shahu, Pundir, & Ganapathy, 2012).
- The performance of the project manager as a team leader, which can be measured via the feedback from all the people who worked with him/her ("Many Shades of Success," 2015).
- "Appreciation of the client, project personnel, users, contracting partners and stakeholders" (Westerveld, 2003, as cited in Müller & Turner, 2007, p. 300).
- For public private partnership (PPP) projects, some of the suggested success criteria include "profitability, reduced public and political protests, reduced litigation and disputes, local economic development, effective technology transfer and innovation . . . effective risk management, reduced public sector administrative cost, reduced project life cycle cost, and satisfying the need for public facility and/or service" (Osei-Kyei & Chan, 2017, pp. 85–87).
- For construction projects in Hong Kong, the top 10 key performance indicators to evaluate project success are as follows (in descending order): (1) safety performance, (2-3-4) cost – time – quality (i.e., iron triangle performance), (5) client satisfaction, (6) effectiveness of communication, (7) end user satisfaction, (8) effectiveness of planning, (9) functionality, and (10) environmental performance (Yeung, Chan, Chan, Chiang, & Yang, 2013).
- For software projects, the study conducted by Agarwal and Rathod (2006) demonstrates that internal stakeholders (i.e., programmer/developers, project managers, and customer account) consider meeting the scope of projects (such as the functionality and quality of the project outcome) as the highest determinants of success.

Turner and Zolin (2012) develop a set of performance indicators for the forecast during the project execution on how stakeholders will perceive the success of the project. Their study brings together a number of success

criteria at different timescales for different criteria and different stakeholders. In this general way, success criteria have been divided by Samset and Volden (2012) into tactical and strategic performance: Success in tactical terms typically refers to the criteria of the iron triangle, which are short-term targets; they are measures of the project's efficiency and are fundamentally the issues of project management. Strategic success, on the other hand, focuses more on the economics and societal matters, which embraces the broader and longer-term perspective of whether the project would have a sustainable influence and remain fit and compelling over its lifespan. The authors support the OECD's comprehensive use of the five success criteria, which are "the project's efficiency, effectiveness, impact, relevance, and sustainability" to evaluate the success of a project, both in terms of tactical and strategic performance (Samset, 2003; Samset & Volden, 2012, p. 48). They add benefit/cost (alternatively cost efficiency) as a sixth criterion.

Success Factors

Success criteria and success factors are two different terms: One is the definition of success (success criteria), and the other is the enabler of success (i.e., success factors). We need to separate project success criteria from project success factors (Koops et al., 2016; De Witt, 1988, as cited in Rota & Zanasi, 2011). In fact, Ika's (2009) literature review of articles between 1986 and 2004 in the main two project management journals identifies very few articles discussing both success factors and success criteria.

As discussed above, success factors comprise managerial tools impacting the success of a project (Cooke-Davies, 2002, as cited in Rota & Zanasi, 2011). Success factors must be specified up front at the concept phase of the project ("Many Shades of Success," 2015). However, due to the enhancement of stakeholders' understanding of their requirements as the project progresses, Thomson (2011) recommends that success factors defined during the project conceptualisation should not remain fixed for the project duration. Instead, the author highlights the need for the project brief to be updated to capture emergent success factors. A summary of main findings in literature on project success factors is presented in the following Table 1.

3.3 Stakeholders

As discussed earlier, a project is considered as successful when it achieves its intended goals and satisfies or surpasses its stakeholders' expectations. Stakeholder management hence plays a core role in successful project delivery. It could be argued that issues about stakeholders are not dealt with thoroughly in the current project management standards (i.e., more toward getting stakeholders to go along with project's needs rather than a "management-for-stakeholders approach," which may be more useful) (Eskerod & Huemann, 2013). Samset (2013) claimed that the design of megaprojects is often undertaken without sufficiently analyzing the interests and needs of key stakeholders.

It is apparent that inadequate understanding of stakeholders' needs and requirements is likely to give rise to either low stakeholder satisfaction or numerous changes during project execution, which might result in extra costs and frustration among project participants. The "fuzzy project front end" is the stage when stakeholders' positions are formed and their potential impacts on the decision-making process are most significant (Aaltonen et al., 2015). The literature survey on project stakeholders undertaken by Achterkamp and Vos (2008) confirms the need for the stakeholders' interests toward a project to be dealt with during the early stages of the project to facilitate project success. This view is further supported by Assudani and Kloppenborg (2010). To be able to do so, a definition of stakeholder, preferably in the form of "a stakeholder classification model," is required. Although evidence shows that even with the use of a sound stakeholder classification model, the identification

Table 1. Main findings in literature on project success factors.

Source	Main Findings
Menches and Hanna (2006)	The study identifies eight common success factors through the review of previous research, including 1) "budget performance," 2) "accurate estimate of cost," 3) "schedule performance," 4) "profit achievement," 5) "planning effort," 6) "management of labor and work hours," 7) "customer satisfaction," and finally, 8) "total team performance and communication."
Fortune and White (2006), as cited in van Niekerk and Steyn (2011)	The authors identify three main success factors, including "support from senior management," "clear and realistic objectives," and "the development of an efficient plan."
Verworn (2009, p. 1573)	The study indicates two factors of project success, including "efficiency" and "overall satisfaction."
Rota and Zanasi (2011)	For international development projects in agriculture, "organizational climate" is considered as a success factor by forming the sense of trust, commitment, and satisfaction between the project manager and project team.
Ika, Diallo, and Thuillier (2011)	Based on the examination of perspectives of World Bank project supervisors and project managers, the authors identify "design" and "monitoring" as the most prominent critical success factors.
Edkins and Smith (2012, p. 166)	At the strategic level, project critical success factors encompass broader stakeholder satisfaction, directly affecting the "social, economic, and natural environment", and possibly having "impact on nebulous areas such as branding and notoriety."
Cserháti and Szabó (2014)	Project management methodologies are a vital success factor in the project front end; whereas the "relationship-oriented" success factors such as project leadership, relationships, and appropriate communication are crucial during the implementation of project objectives.
Blaskovics (2016)	The study suggests nine groups of success factors, of which some are activities occurring during the front end of a project, such as the clarity of the project's underlying strategic goals, the definition of the project scope, and the project's organizational and environmental characteristics.
Bayiley and Teklu (2016, p. 562)	The study identifies four sets of critical success factors for projects funded by the European Union, including "intellectual capital, sound project case, key manpower competency, and effective stakeholder engagement." Furthermore, the descriptive statistics of their survey emphasized five critical success variables, including "clear policy of donors and recipient government, strong local ownership of project, effective consultation during planning, high motivation and interest, and compatible rules and procedures."
Achterkamp and Vos (2008)	The study suggests considering stakeholder involvement as a critical success factor.

of a project's stakeholders is still a considerably challenging task (Achterkamp & Vos, 2008). The reason for this is clear: A complex project usually draws interest from multiple stakeholders who express various requirements and expectations that are often in conflict with each other; it is improbable to satisfy all of them (Olander, 2007).

Several attempts have been made to develop a stakeholder classification framework to help formalize a stakeholder management process. For instance,

- Olander (2007, p. 277) develops a fundamental "stakeholder impact analysis" comprising: (1) a "stakeholder impact index" to identify the essence and effect of stakeholder impact; (2) the likelihood of stakeholders exercising their impact; and (3) the position of each stakeholder with regard to the project (i.e., whether they are supporters or opponents).
- Achterkamp and Vos (2008, p. 752) advocate the use of a structured "role-based stakeholder classification model" (based on the stakeholder literature and the project roles in the project management literature) for stakeholder identification and classification at the very outset of a project. Their model divides the roles stakeholders play in an innovation setting into two main categories: actively involved (i.e., client, decision maker, and designer) and passively involved.
- The findings of the study undertaken by Lenferink, Tillema, and Arts (2013, p. 615) shows that integrated delivery mechanisms for "design-build-finance-maintain projects" might enhance inclusiveness in key project stakeholders and thus result in more "sustainable infrastructure development" because of the life cycle optimization incentives.
- Aaltonen et al. suggest the use of a stakeholder-salience-position matrix in analyzing and classifying project stakeholders instead of the commonly applied power-interest matrix which does not take into consideration the nature of a stakeholder's interest in the project. Their findings further support previous "research that describes the front-end phase as an iterative and drifting process of organizing that is influenced by various stakeholder influences and stakeholder management episodes" (2015, p. 28). One of the cases in their empirical study shows that due to high political pressure during the project's front end, non-business stakeholders play a more crucial role in the decision-making process. The authors also demonstrate that inflexible stakeholder management processes may lead to adverse stakeholder dynamics in the later phases of the project.
- Revellino and Mouritsen (2017) offer an unusual view of stakeholder analysis to concentrate on the objects that matter to those stakeholders, using the philosophy of Latour.
- For infrastructure projects, Mostafa and El-Gohary (2015) propose a stakeholder management scheme considering both the benefits and needs of project stakeholders and trying to achieve the highest social welfare.
- Where the stakeholder structure is complex, such as in megaprojects, social network analysis is used to identify and prioritize stakeholders (Assudani & Kloppenborg, 2010; Mok, Shen, & Yang, 2015; Williams, Ferdinand, & Pasian, 2015).
- Li, Ng, and Skitmore (2016) propose a number of methods using the decision rule approach to facilitate the decision-making process in a multi-stakeholder, multi-objective project.

It is essential to build good relationships with key stakeholders and to secure their commitment during the early stages of a project. This practice is apparently more important for some types of project delivery system than others (Hellström, Ruuska, Wikström, & Jåfs, 2013). Effective stakeholder communication practices might help ensure fruitful engagement with project stakeholders and consequently lead to a higher chance of achieving a

comprehensive set of stakeholders' needs and requirements. Due to the varying degrees of stakeholder salience over the course of the project (Assudani & Kloppenborg, 2010), different communication approaches and techniques are required at different points in time for different stakeholders (Turkulainen, Aaltonen, & Lohikoski, 2015). For example, communication during the project front end concentrates on the project's content and plan, along with the establishment of behavior rules and clarification of project objectives (Katzenbach & Smith, 1993, as cited in Turkulainen et al., 2015).

Facilitated and structured workshops also form a key part of the stakeholder assessment during the early briefing phase of a project, and Thyssen, Emmitt, Bonke, and Kirk-Christoffersen (2010) have demonstrated how these are used to identify stakeholders' ideas of "value." For major public projects, public opinion is becoming more and more involved in the whole life cycle of a project; and thus, a harmonious relationship with the public is essential for attaining project objectives (Hanchen et al., 2016). With the rapid growth of social network sites, an efficient sentiment analysis process can enable projects to increase public involvement (Hanchen et al., 2016). Hanchen and colleagues (2016) developed a project sentiment analysis methodology, employing lexicon-based techniques that gather user opinions from social network services, create emotion dictionaries, and form basic rules that analyze those sentiment values.

The management of stakeholders would be a more straightforward task if stakeholders' needs and expectations were in harmony. However, this is unfortunately not often the case. For example, Hongping (2017) shows that different groups of stakeholders usually have different understandings of a project based on their own experience and individual interests. Hence, a better understanding of the possible conflicts of stakeholders would significantly contribute to better stakeholder management. The study by Boudet, Jayasundera, and Davis (2011) suggests several drivers of conflict among stakeholders in global infrastructure projects and groups them into three broad groups: "contextual factors, project characteristics, and local impacts" (p. 499). For better management of contradictory claims of stakeholders, an argument-mapping technique is proposed by Metcalfe and Sastrowardoyo (2013) which enables the project team to visualize an argument in an easy-to-be-amended-and-discussed structure.

These issues are particularly acute in megaprojects, which are often highly contested and approached by a wide variety of stakeholders. Van Marrewijk (2015) looks into a number of projects as cultural phenomena, focusing on practices and micro processes within the project and the human networks with stakeholders in society. Some advices on the public engagement process in mega development projects are also given by Leung et al. (2014).

3.4 Benefits/Needs

Projects are a means to create value and deliver benefits (Morris, 2009). A chain of benefits introduced by Serra and Kunc (2015) shows how benefits are linked to organizational strategy and business objectives. The hierarchical chain starts with the organization's strategic goals at the highest level, followed by end benefits, intermediary benefits, and desired outcomes. The identification of desired benefits during the preparation of a project's business case is a crucial step supporting the clarification of the fundamental motivation behind the investment decision (Project Management Institute, 2016b). It is evident that organizations can gain more benefits from projects when benefits are unambiguously articulated in the early front-end planning stage (Marnewick, 2016; Terlizzi, Albertin, & ~~and~~ de Moraes, 2017), even though all potential benefits cannot necessarily be known at this stage (Doherty, Ashurst, & Peppard, 2012). However, this activity

often takes place with inadequate attention from senior management, leading to additional time, cost, and performance issues at later phases (Edkins & Smith, 2012). PMI's (Project Management Institute, 2016a) study shows that less than half of organizations identify desired outcomes before project initiation. To ensure only right investments are selected, it is important that benefits are not overstated at this early stage of the project (Shiferaw & Klakegg, 2012).

In a project there may be stakeholders who benefit from the project and those who endure disadvantages or losses. Hence, it is necessary to ensure that on the one hand, the project maximizes the benefits given to the key stakeholders, but on the other hand, limits the disadvantages or has strategies for dealing with those who may suffer them (Edkins & Smith, 2012). McLeod, Doolin, and MacDonell (2012) indicate that stakeholders will have different perceptions of project success and therefore result in various types of benefits related to different stakeholders such as business benefits, user benefits, project team benefits, and strategic benefits. Therefore, Turner and Zolin (2012), as mentioned in Section 3.2, try to develop a set of "leading performance indicators" for the estimate of how various stakeholders will perceive the success of the project in different points in time. Keeys and Huemann (2017) consider benefits co-creation as a strategy for creating benefits for a large group of stakeholders. Their study shows how co-creation between multiple stakeholders (who have their own views on benefits, value creation, and risk concerns) can enable the shaping of project benefits. Moreover, facilitated/structured workshops are important practices that can be used before the project is formally launched to assess stakeholders' opinions on the project value (Thyssen et al., 2010). For enterprise resource planning projects, a holistic, organization-wide consideration of needs and understanding of what existing solutions and technologies can do is essential (Millet, 2013).

Before decisions on the choice of a concept solution are made, a thorough understanding of stakeholders' needs and requirements is crucial to shaping the desired benefits (Edkins & Smith, 2012). Interestingly, stakeholders' wants and needs are sometimes confused, although they are completely different terms (i.e., what stakeholders want doesn't necessarily match with what they need). The distinction between wants and needs is even more complex and ambiguous in large public projects where stakeholders often possess different and conflicting sentiments and priorities about needs (Næss, 2009). Subsequently, it may be challenging to explicitly declare to what extent there is a need for a project. Næss (2009) provides guidelines on how an assessment of needs could be done up front in major public investments to prevent the exaggeration of needs. A description of the process (beginning with the identification of the client's requirements, followed by how they are translated into a strategic brief, and eventually, how this is then transformed into a project brief) is presented in the study by Nina and Sven (2007). Section 6.2.2 of this study will present the findings of the literature on methods used in estimating project benefits.

3.5 Preferences

Not all projects are selected following a rigorous selection process. Sometimes, perhaps, often, the project concept might be determined in advance without considering alternatives. Simply put, the project could be chosen based on the interest of only one individual or a specific group of key stakeholders, or it could be the result of political preferences or pressures (Williams & Samset, 2010). There is usually a confusion between stakeholder needs and preferences. It is not a rare case that project promoters integrate their own preferences into the project selection process, leading to the adoption of more favourable investments (Næss, 2009). This is discussed further in Section 5.2.

3.6 (Perverse) Incentives

Strong incentives on behalf of the initiating party may be a prerequisite for a successful project. But not always. Public investments, especially those with no financial commitments for the project promoters, may cause perverse incentives that lead to the misallocation of public funds, waste of taxpayer money, and negative impacts such as corruption (Samset & Volden, 2016).

There is much literature on incentive problems in economic literature, but less so about perverse incentives. A pivotal study concerns Swedish-funded investment projects (Ostrom, 2001) where the phenomenon is linked to transfers that occur in such a large scale that one could talk about the emergence of a gift economy in the recipient country.

The theoretical basis for understanding the phenomenon is principal agent theory, which deals with issues that may arise in the relationship between a party who owns the goals (principal) and another actor (the agent) whose actions are important to goal achievement. (Jensen & Meckling, 1976) and (Laffont & Martimort, 2002).

Perverse incentives can be defined as an extreme degree of the incentive problem. It refers to a situation where the encouragement of one or more agents to make choices results in an unintended or undesirable project, which is opposed to the interests of the principal (i.e., the funding party, government, society). To prevent or mitigate the adverse side effects caused by perverse incentives, Samset and Volden (2016, p. 309) suggest a twofold solution which is similar to the Norwegian quality assurance regime: First, aligning the objectives of project promoters with governmental goals through, for example, "co-financing and local risk taking" requirements; and secondly, lessening "information asymmetry" problems by implementing, for instance, "information control, external review, and public hearings."

3.7 Logframe

A particular approach to project management that should be highlighted is "logframe," the Logical Framework Approach to Project Cycle Management or LFA. This system was created in 1969 for the U.S. Agency for International Development, and is discussed in Baccarini (1999). The key element of the Logical Framework Approach (LFA) is that it explicitly links highest-level goals (i.e., organizational strategy – strategic goals), intermediate outcomes (i.e., project target benefits – tactical goals), outputs (i.e., iron triangle – operational goals), and inputs of a project. In this way, it embodies the view that projects should be driven by the outcomes and justified by the strategic goals. Part of the rationale of the framework is that projects are considered as a structured form of discovery (i.e., they are operating under uncertain and unknown conditions, and must be open for change).

The power of logframe comes in the front end of the project, where it is used to create clear objectives and build commitment and ownership among the various stakeholders. It is a qualitative analysis of causalities and judgmental probabilities that does not necessarily require quantitative information, and therefore is particularly useful at a very early stage when little information exists. Having set up the project this way, the idea is that logframe is used for managing the complete project cycle from design to implementation, monitoring, and evaluation. Some have found it difficult to use within today's conventional project management framework and to integrate with commonly used project management tools. Couillard, Garon, and Riznic propose a slightly updated version of logframe to "improve its compatibility with today's corporate culture, project management framework, and tools" (2009, p. 31). A next step in the evolution of LFA is the contemporary results-based management (RBM) strategy composing of three elements, namely, the strategic link, project design, and project performance measurement (Ssegawa & Muzinda, 2016).

4. Initial Analysis

Now that the initial idea for a project is defined, an initial analysis can be carried out. However, this is usually within an environment of uncertainty and complexity, and we consider these aspects here. We need to remember that we are looking at the environment of the suggested initiative, and are not yet looking at the risk of a particular solution.

4.1 Uncertainty (and Risk)

Uncertainty about the future is one of the prevalent issues encountering the management of front-end activities. It is often thought to have its root cause in the difference between the information one has and the information one requires to make a decision (Samset & Volden, 2016). As a result, decision making becomes challenging when uncertainty is high. It is a generally held view that uncertainty is most elevated at the earliest stage of a project and then tends to decrease as information accumulates over time (Winch, 2010; Samset & Volden, 2016). Samset and Volden (2016) hence consider the project front end as the time when the potential to mitigate uncertainty and risk is most significant; this ability then diminishes considerably when the project is executed. Therefore, more time and resources should be spent on researching and acquiring information from the earliest stage of the project (Samset & Volden, 2016).

Uncertainty can be negative or positive (negative as detriments and positive as opportunities), and can originate from causes both internal and external to the project (Perminova, Gustafsson, & Wikström, 2008). Risk can be defined as "any uncertain event that might fail to serve the interests of stakeholders as stated in the project design" (Young, 2010, as cited in Sanchez-Cazorla et al., 2016, p. 77), although this limits the definition to "events." An APM risk publication (Association for Project Management, 2008) is clear that risk needs to contain uncertain parameters as well as distinct events. However, uncertainty management in the project context has traditionally been referred to solely risk management (Hillson, 2003). There has been a tendency to use them synonymously, which in effect implies that uncertainty is either treated similarly as risk or overlooked (Sanderson, 2012). This tendency is dangerous since it might encourage the emphasis on operational planning and control risk, leaving opportunities unexploited (Johan[illegible] Eik-Andresen, Landmark, Ekambaram, & [illegible]stadås, 2016; Sanderson, 2012). As a consequence, Ward and [illegible]pman (2004) introduced the term *uncertainty management* as an umbrella term of risk management and opportunity management, concentrating on exploiting opportunities along with mitigating risks.

It has commonly been assumed that threats are bad whereas opportunities are good. However, as Edkins and Smith (2012) emphasize, that opportunity also has the potential to disrupt the project. This happens, for example, when senior management expects such opportunities to be pursued without supplementing additional resources. As uncertainty implies both risk and opportunity, traditional risk management tools such as planning, monitoring, and controlling are not enough for managing uncertainty (Perminova et al., 2008). The measures of both uncertainties and probability of risks are crucial to the estimation in any project (Williams & Samset, 2010).

Uncertainties can be regarded as being of two forms: aleatoric (i.e., those to which probabilities can be objectively related) and epistemic (i.e., those stemming from a lack of sufficient knowledge), with many combining both aspects (Williams & Samset, 2010). Indeed, these ideas go back to Knight (1921). Sanderson (2012, p. 435) uses Knight's theory to divide risk into "a priori probability" and "statistical probability," and uncertainty into "subjective probability" and "socialized probability." A priori probability refers to the situation

where the decision makers think they can allocate "objective probabilities" to known future events using "mathematically known chances." Statistical probability refers to the situation where the decision makers think they can allocate "objective probabilities" to known future events using "empirical/statistical data about such events in the past." Subjective probability refers to the situation where the decision makers think they encounter a "known range of possible future events," but do not have enough required data to allocate objective probabilities to each of those events. In such cases, they employ expectations scripted and grounded in historical practice to predict "the subjective probability of future events," which is similar to scenario planning. Socialized probability refers to the situation where decision makers think they encounter a circumstance where the characteristics of future events are unknown.

The finding from the study by Miller and Hobbs demonstrates that major projects are exposed to numerous types of risk and an extremely high level of uncertainty. They describe the three most important sources of risk, including governments defaulting on their commitments, gradually evolving or deficient markets, and "social and political challenges to legitimacy" (2005, p. 43). They also point out three main sources for the high level of uncertainty, namely, the vast number of possible causes of risk, the project's clarity, and the project's approach to innovativeness. For public-private partnership (PPP) projects, the procurement process is characterized by its complexity, highly competitive environment, high resource cost, and length of time. Thus, risk related to the choice of a suitable procurement route should be efficiently managed for the achievement of long-run success (Doloi, 2012). Furthermore, the lengthy period of time required to develop a project increased its exposure to emergent risk (Doloi, 2012). Miller and Hobbs (2005) show that projects embedded in robust institutional frameworks have a better ability to endure and survive the impacts of emergent uncertainty.

Sanchez-Cazorla et al. (2016) conducted a systematic literature review of risk management in megaprojects. They provide a comprehensive categorization of risks, in which a total of nine main risks have been identified and described, including design risks, legal and/or political risks, contractual risks, construction risks, operation and maintenance risks, labor risks, customer/user/society risks, financial and/or economic risks, and force majeure risks. In general, project risk can be divided into systemic risks and project-specific risks (van Niekerk & Bekker, 2014). Disruptive events are one of the major systemic risks that are often overlooked. It is suggested that senior management should carefully plan for such events, create an environmental scanning procedure, and utilize a responsive decision-making model to both mitigate the impact and/or to exploit such an event when it happens (Pells, 2016).

Ward and Chapman (2008) later regard stakeholders as a significant source of uncertainty, including who they are, how they could affect the project, and what their motives are. The authors' findings show that a systematic stakeholder management approach is facilitated by the employment of project uncertainty management methods that distinguish different phases of the project life cycle. The methods used for analyzing project risks will be discussed in detail in Section 6.2.8.

Chung-Li, Tong, and Fu (2009) try to identify uncertainties facing a construction project to incorporate them into contingency estimation. Their study recognized three uncertainties faced by construction owners, namely, cost, scheduling, and technology uncertainty. They also found that the primary sources of uncertainty from the owner's perspective include the random variation of component performance, imprecise or insufficient data, and failure to predict reasonably because of the lack of related experience. Regarding risks related to construction projects, some specialists have classified them as contractual or technical (Touran, 2008).

Bedford (2009, as cited in Williams & Samset, 2010), separates the areas of uncertainty further into three categories and describes some "probabilistic models" for investigating the initial two of these and supporting the third. The three groups of uncertainty comprise insufficient knowledge about the main uncertainties and their synergies; the extent of project exclusivity; and the manner in which forthcoming decisions will influence outcomes" (Williams & Samset, 2010, p. 44).

Using data from 144 projects completed by German firms, Verworn (2009) finds that market and technical uncertainty remaining at the start of a project negatively affect communication and increase deviations during project execution. The author also finds that effort spent on mitigating uncertainty during the project front end may be influenced by the level of the novelty of new product concepts. Novelty is considered as a key aspect of projects that determines how the project is thought about (Brockhoff, 2006). Oh, Yang, and Lee (2012) recommend the use of a decision-making framework employing a fuzzy expert system in portfolio management for dealing with the uncertainty of the fuzzy front end of product development.

Successful uncertainty management requires continual engagement in learning and sensemaking as facilitators of flexible and rapid decision making about the selection of alternative actions in response to the situation (Perminova et al., 2008). According to Perminova and colleagues (2008), this iterative process of learning and sensemaking might, in turn, mitigate uncertainty by translating it into "known risk and opportunities." Therefore, well-structured and standardizing procedures which make the lessons learned easily obtainable within the project team constitute an essential basis for facilitating these reflective processes. Continuously employing such schemes at different project phases is thus crucial to project success (Perminova et al., 2008).

Edkins and Smith (2012) recommend the use of Performance Uncertainty Management Processes (PUMP) developed by Ward and Chapman (2011) for its balanced view between the matters to be overcome and the opportunities to be grasped. They are strongly against the use of the risk register as a reporting tool rather than an ongoing management tool due to the dynamic of both project and project risk. Instead, the use of the risk register to manage contingency and mitigation should be included in the project design.

Beside uncertainty, equivocality is another vital characteristic that constitutes the fuzzy front end of innovation projects (Frishammar, Florén, & Wincent, 2011). Despite this, very few studies have investigated the adverse consequences of equivocality on the project front end and solutions to mitigate them. The research conducted by Frishammar et al. (2011) deepens the understanding of the front end by showing that both uncertainty and equivocality are more efficiently controlled in successful front-end projects than in failed ones, and that the negative impacts of equivocality surpass those of uncertainty. Their study also reveals that the ability of organizations and project teams to reduce uncertainty and equivocality is more important than their ability to choose projects with low levels of uncertainty and equivocality. Some suggestions to mitigate equivocality include effective communication strategy and making use of "integrators" which can help organizations overcome disagreements.

4.1.1 Scenario Analysis/Planning

Having defined what is meant by uncertainty in the project environment, the study now moves on to discuss an important method used in concept/option selection during the project front end under the condition of uncertainty: the scenario analysis, also called scenario planning.

Organizations adopting a long-term view are more likely to be implementing planning practices focused on exploiting opportunities and reducing threats (Harris & Ogbonna, 2006). Pinter and Leitner (2014) state that scenario analysis is by far the most popular method of corporate foresight. Scenario analysis is a vital technique to enhance the quality and effectiveness of strategic planning in the front end of NPDs (Postma, Broekhuizen, & van den Bosch, 2012), especially in dealing with future uncertainties (Hanafizadeh, Kazazi, & Jalili Bolhasani, 2011), and transferring new ideas to the innovation process (Brem & Voigt, 2009). By employing scenario planning techniques during the project front end, organizations could create the political, economic, and technological scenarios for the design of their project portfolio (Hanafizadeh et al., 2011).

Heijden (2009) emphasizes the vital role of scenario planning in making judgment at the project front end, under conditions of uncertainty and scant information when a project's purpose and scope are still underdeveloped. According to Heijden, scenario planning is an "exploratory process" for analyzing a project's business environment based on integrating global knowledge in order to reduce uncertainty. His study regards scenario planning as an iterative "outside in" process (p. 69) including four stages (p. 79): (1) "context setting and boundary definition;" (2) "knowledge elicitation and systems analysis;" (3) "driving force categorization, framework definition, and scenario building;" and (4) "implications study."

Saaty (2015) encourages the use of scenario planning instead of spreadsheets and "silver bullets" in selecting R&D projects. The author cites a study by Ventana Research which reveals that the success rate of a company in choosing the right initiatives to invest in is 89% when it can explore all scenarios around a given issue, compared to 55% when it cannot.

Bañuls, López, Turoff, and Tejedo (2017) discussed various techniques used in scenario analysis. They suggest the combined use of cross-impact analysis and interpretive structural modeling (ISM) approaches to enhance the predictive capacity of existing risk analysis technique.

Based on the concept of scenario planning, Moret and Einstein (2012a) develop an estimation model simulating project uncertainty with probability distributions, correlations, and disruptive events and show how decision biases occur in probability estimation.

Beside the traditional scenario planning, real option analysis is a new way to value investment under uncertainty (Miller & Waller, 2003). These two approaches have complementary strengths and weaknesses and thus are combined by Miller and Waller (2003) in an integrated risk management process. Many scholars have investigated the use of real options analysis for project estimation (see, for example, Chang, 2013; Hawes & Duffey, 2008; Kodukula & Papudesu, 2006; Wang & Yang, 2012). Kodukula and Papudesu (2006) view real options analysis as a useful technique where management flexibility is taken into account in the project valuation. Based on the novel idea of "risk-bearing capacity," Chang recommends development of a new method in which investors can integrate the choice of financial protection means into the evaluation of the investment in a coherent approach (2013, p. 1057).

4.1.2 Scant Information

As discussed earlier, most important choices are made during the project front end when uncertainty is at its highest and availability of information is at its most limited (Samset & Volden, 2016; Williams & Samset, 2010; Winch, 2010; Yim, Castaneda, Doolen, Tumer, & Malak, 2015). It is widely believed that a lack of information leads to poor project decisions. But contrary to this common belief, Williams and Samset (2010) and Samset and Volden (2016) support the view that the lack of detailed information during the project front end can, in fact, be

a benefit rather than an obstacle in providing decision makers with concentration and pliability. According to the authors (Williams & Samset, 2010, p. 45; Samset & Volden, 2016, p. 302), a crucial issue during the front end is not the quantity but what type of information is required. Limited, but carefully selected, information may help avoid "analysis paralysis" which refers to the situation when an excessive amount of detailed information is presented to decision makers too early in the decision-making process.

Samset and Volden (2016) later point out that detailed and specific information tends to lock decisions into the initially favored concept, to the degree that this has a high likelihood of being the one that is eventually selected; not to mention that the more detailed the information is, the faster it becomes outdated. This highlights the need to invest in the targeted search which only focuses on obtaining the purely relevant information at the earliest stage of a project (Samset & Volden, 2016). It is therefore critical that one thinks carefully about what information to use during the front end (Kutsch & Hall, 2010).

Essentially, the availability of information in the earliest stage of the project depends considerably on the novelty of the project concept (Grau & Back, 2015). Samset and Volden (2012) recommend that "creativity, imagination, and intuition" can be more valuable at this phase than expansive quantity of information. Bartkowiak and Rutkowski, in their recent study, have specified eight main types of information that the decision makers have to attain in supporting decision-making processes in the pre-project phase of NPDs, including the "the strategic, financial and program management, new product design (internal sources), technical, the customer and their needs (internal and external sources), and competition and regulations (external source)" (2016, p. 113).

4.2 Complexity

Extensive research has been carried out on project complexity due to its contribution toward project failures regarding time delays and cost overruns (Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011; Mirza & Ehsan, 2017; Qazi, Quigley, Dickson, & Kirytopoulos, 2016). While a variety of scholars have tried to define project complexity, there is still a lack of a commonly accepted definition (Chapman, 2016). For example, Vidal and Marle (2008, p. 1101) defined project complexity as "the property of a project which makes it difficult to understand, foresee and keep under control its overall behavior, even when given reasonably complete information about the project system." Priemus, Bosch-Rekveldt, and Giezen (2013) highlight the crucial role of risks and uncertainties in the creation of project complexity.

At this stage, as Chapman (2016) emphasizes, we need to distinguish between complexity originating from within the project itself (i.e., uncertain objectives and scope, usage of novel technology, and decision of organizational structure, project management framework, and contracting strategy) and complexity stemming from a project's context (i.e., evolving expectations of external stakeholders, definitions of project success and the relationships between them) since they require different treatment. In the front-end phase there is not yet a complete or fully defined project, so we are interested in contextual complexity, although we mention project complexity here since it clearly draws heavily from the contextual complexity (Chapman, 2016). Chapman goes on to define a complex project as "one which exhibits a high degree of uncertainty and unpredictability, emanating from both the project itself and its context" (2016, p. 938).

Megaprojects are qualitatively more complex and uncertain, and therefore have a more extended and complex "front end" (Miller & Hobbs, 2005). Complexity is considered as a core characteristic of the decision-making process in megaprojects (Priemus et al., 2013). Miller and Hobbs (2005) identify a set of design criteria that

ought to be taken into account when developing a governance regime for megaprojects. Some of these criteria oppose the traditional conception of governance, such as megaprojects are "network relations" rather than "binary relations," "evolution and indeterminacy" rather than "established process," "co-evolution" rather than "set by governing body," governing bodies do not always make responsible choices, the project promoter does not always behave sensibly, the state is the project participant rather than the independent body, and the moral high ground is not always occupied (Miller & Hobbs, 2005, p. 46). As complexity of megaprojects is enlarged by market dynamics and political discontinuity in an evolving environment, adaptive capacity is the key in dealing with complexity (Priemus et al., 2013).

There are many approaches to categorizing project complexities. For example, complexity is divided by Torp and Klakegg (2016) into structural, technical, directional, and temporal complexities. Brady and Davies (2014), on the other hand, collapse the various dimensions into structural and dynamic complexity and look at how high-complexity projects can be managed dependent on these dimensions.

Perhaps the most well-known categorization of project complexity is by Geraldi, Maylor, and Williams, who try to capture the various aspects of the complexity of projects by characterizing these aspects using five dimensions: "structural, uncertainty, dynamics, pace, and socio-political" (2011, p. 984). In public projects, in particular, the stakeholder and political environment increases the complexity associated with the last of these dimensions (Klakegg, Williams, & Shiferaw, 2016).

As increasing complexity is one of the primary reasons behind the failure of many projects, identifying and measuring complexity is critical to the success of any project. In 2011, Bosch-Rekveldt et al. proposed a framework aiding the characterizing and understanding of project complexity during the front-end development phase of projects by focusing on the richness of complexity in large engineering projects. They have identified 50 elements contributing to project complexity in the literature, which were then grouped under three areas: technical, organizational, and environmental complexity. He, Luo, Hu, and Chan (2015) proposed another way of measuring complexity for megaprojects by employing the fuzzy analysis network process (FANP). Based on the review of the literature on project complexity, their model consists of 28 factors grouped under six categories, namely, technological, organizational, goal, environmental, cultural, and information complexities (He et al., 2015).

Chapman (2016) has recently developed a complexity framework which considers the dynamic nature of projects and places emphasis on aspects of complexity derived both from within and outside a project. In 2016, in order to help capture interdependency among complexity, risks, and project goals during the commencement stage of a project, Qazi et al. (2016) put forward a model concentrating on the interface of project complexity and interdependency modelling of project risks. Mirza and Ehsan (2017) try to understand the factors causing project complexity, and the influence they have upon a project. They classify complexity factors into three categories based on the concept of the iron triangle, namely, cost/resource complexity, schedule complexity, and scope complexity. To support the identification and measurement of complexity during the planning phase, they develop a complexity measurement tool encompassing all three complexity factors called Project Execution Complexity Index (PECI) tool.

Rather than discussing time and cost overruns in megaprojects, Giezen (2012) tried to shed light on the disadvantage of reducing complexity in the planning of megaprojects. According to Giezen, the most important drawback is that the project could become too simple, which in turn leads to, for example, the ignoring of project strategic potential, new ideas and critiques during the early stages of the project, and the loss of the

adaptive and strategic capacity. And thus, the author encourages the utilization of a decision-making process that accommodates impacts and strategic inputs from external sources but keeps a tight rein on techniques and design in order keep the project simple but still accomplish the most value.

4.3 The Project Appraisal/Evaluation Process

Samset (2003) defines project evaluation as a process evolving comprehensive studies of projects' progress, outputs, and impacts to provide decision makers with relevant and reliable information. Evaluation can be conducted at any stage of the project life cycle (Irani, 2010; Samset, 2003). Thus, while this section comes here, as the general idea of an initiative is evaluated, it will cover the evaluation and appraisal process right through the front end, and is relevant even when the (now defined) project is nearing sanction.

The early assessment of the project is called project appraisal (Samset, 2003), or feasibility study (Alkass, Luo, Hu, & Chan, 2006), or ex-ante evaluation (Irani, 2010; Bulathsinhala, 2015), which is done to decide whether or not to invest in the project and go ahead with it (Bulathsinhala, 2015). Due to the lack of a strong culture of identifying genuine alternative concepts as the foundation for project design, a significant challenge which decision makers face in the front-end stage is to recognize and evaluate feasible concepts (Williams & Samset, 2010). An international study of 60 large infrastructure programs (IMEC, 1999, as cited in Samset & Volden, 2012) reveals that less successful projects were typical results of authoritative choices made by influential interest groups, which were often initiated under time pressure and with few resources assigned to the evaluation or appraisal of concepts. Thus, the original initiatives were selected based on assumptions imposed by interest groups without acquiring sufficient relevant information and considering several alternatives, including the zero or "do nothing" option. Subsequently, with no surprise, many cases ended up with projects which have objectives that conflict with their organizations' strategic goals.

With reasonable effort, an acceptable view of whether a concept is relevant and sustainable should be achievable. Poor early evaluation usually occurs not because proper assessment is impossible, but because evaluation is not being done to an adequate extent (Samset & Volden, 2012). It is also well known that a formal appraisal of exploratory projects will often stop them since they do not ex-ante provide sufficient arguments to guarantee direct profitability or benefit production, although such projects are essential in renewing a firm's assets and/or creating new business opportunities (Samset & Volden, 2012). The study conducted by Maniak, Midler, Lenfle, and Pellec-Dairon (2014) suggests ways of viewing potential value and taking a real options approach to make rational decisions.

The decisions made on major investments are usually preceded by some ex-ante evaluation methods focusing on assessing the future impacts of the investments (Raschke & Sen, 2013). Appropriate methods for ex-ante evaluation can subsequently improve the selection of the suitable concepts. Alkass et al. (2006) indicate three traditional main approaches in project feasibility (i.e., financial, technical, and economic feasibility studies), and additional factors that can be considered include reputation, public and customer relationships, project portfolio's diversification, as well as risk. By studying the ex-ante evaluation of rural development programs in the EU, Vidueira, Díaz-Puente, and Rivera (2014) indicate a variety of pointers, including the use of dynamic behavioral techniques and nonparametric estimations to get control of the complexity of impacts produced by programs.

Several attempts have been made to explore ex-ante evaluation methodologies where qualitative and/or quantitative can be employed for the evaluation. Some suggestions are, for example:

- Using the balanced scorecard method for the evaluation of information and communication technology projects (Milis & Mercken, 2004).
- Combining the concept of scenario analysis with that of sensitivity analysis to overcome the inadequacies of the traditional sensitivity analysis and taking into account a probability that each variable will change within a possible range (Alkass et al., 2006).
- Not using ex-ante evaluation in isolation but rather grounding it against "a backdrop of the strategic grid, where techniques such as those offered by the operational research community can be used to appraise such investments" (Irani, 2010, p. 927).
- Implementing a build-operate-transfer (BOT) credit risk model, of which key inputs include credit ratings, market data, and financial information, to analyze default risk and loan losses in infrastructure projects (Kong, Tiong, Cheah, Permana, & Ehrlich, 2008).
- Using cost benefit analysis in decision making (Annema, 2013; van Wee & Rietveld, 2013).
- Incorporating ethics in the ex-ante evaluation of megaprojects to overcome several limitations of CBA (van Wee, 2013).
- Employing "multi-actor and multi-criteria analysis" in evaluating megaprojects (Macharis & Nijkamp, 2013).
- Undertaking risk analysis concerning the socio-economic feasibility to produce stochastic interval results in preference to the traditional deterministic point results (Salling & Leleur, 2015).
- Using activity-based management as a standardized technique to improve the cost estimation of international projects (Vereen, Sinacori, & Back, 2016).
- A summary of very simple project selection and evaluation methodologies used for U.S. government IT projects is given by Rosacker and Olson (2008). Chiang, Cheng, and Lam (2010) introduce three reliable internal rate of return methods for appropriate project evaluation and ranking for projects using the Private Finance Initiative (PFI). A simple program for working out cash flows for a developing country construction project is provided by Halawa, Abdelalim, and Elrashed (2013). The study conducted by McLeod et al. (2012) uses a subjectivist perspective to investigate how various project stakeholders perceived the project outcome and what evaluation criteria they drew on and how they are changed over time.
- Project evaluation is well established in the public sector. Different countries have different tools and procedures for evaluating major public projects. Examples include:
  - The "Five Case Model" approach is used in the UK for the development and appraisal of public projects' business cases for the purpose of spending decisions regarding, for example, scoping and option evaluation (HM Treasury, 2011, 2013).
  - In Australia, the Department of Infrastructure and Regional Development (Australian Transport Assessment and Planning [ATAP] Steering Committee, 2016a, 2016b) employs the "Transport System Management Framework" to provide support for planning and decision making in infrastructure projects; and the Commonwealth of Australia – Department of Finance (2014) uses the "Two Stage Capital Works Approval Process" to provide entities with instruction and direction when seeking approval to undertake construction capital works.
  - "Policy on the Management of Projects" is issued by the Treasury Board of Canada Secretariat (2012b) to ensure projects proposed for approval can receive informed and valuable consideration. This policy is supported by the Standard for Organizational Project Management Capacity (Treasury Board of Canada Secretariat, 2012c) and the Standard for Project Complexity and Risk (Treasury Board of

Canada Secretariat, 2012d). The two scores resulting from these two assessments are compared to determine the appropriate expenditure and to notify the determination of Treasury Board oversight (Treasury Board of Canada Secretariat, 2012a).

- Ex-ante impact assessment has become an obligatory task when establishing a new project/program in the European Union (EU) (Vidueira et al., 2014). For projects funded by the European Union, the "Guide to Cost-Benefit Analysis of Investment Projects – Economic Appraisal Tool for Cohesion Policy 2014–2020" (European Commission, 2015) presents the regulatory requirements for the project appraisal process and the related decisions on a major project. It also discusses cost-benefit analysis (CBA) guiding principles, working rules, and analytical steps that shall be considered for investment appraisal under EU funds. Besides that, "The Economic Appraisal of Investment Projects at the EIB" (European Investment Bank, 2013) presents the economic appraisal methods that the European Investment Bank uses to assess the economic viability of projects.
- In Norway, the Quality Assurance Gateway System is used during the project front end, including two checkpoints where measures are taken to ensure the quality of documentation. The two checkpoints include: (1) before the Cabinet's decision regarding conceptual solution; and (2) the Parliament's approval of the project's cost frame (Samset & Volden, 2013).
- In the United States, the "Analysis of Alternatives" (AoA) issued by the Department of Energy – Office of Project Management Oversight and Assessments (2017) is an analytical comparison of the operational effectiveness, suitability, risk, and life cycle cost (or total ownership cost, if applicable) of alternatives that satisfy validated capability needs. An AoA must be performed when a mission needs statement is put forth to verify that no existing alternative could fulfill the proposed option.

Lepori, Van den Besselaar, Dinges, Van der Meulen, Potì, Reale, and Theves (2007) point out the notable shortcoming of investigation considering the entire organization and portfolio of project funding instruments in a country that enables comparative analysis between various nations across periods of time. The authors developed a methodology for systematically producing project funding indicators based on the accumulation of information straightforwardly from the funding agencies and, on this premise, generating a set of comprehensive comparative analyses of public systems in European nations. Bulathsinhala (2015) and Feller (2007) recommend some policy considerations that should be taken into account when shaping the ex-ante evaluation agenda in the selection of R&D projects.

5. Project Concept

5.1 Concept Definition

Having established the set of needs that trigger or drive a response, the various project concepts that could answer those needs have to be identified, and one chosen. "The generic notion of a concept designates an abstract idea or model that corresponds to something concrete in reality or in language. As used in the context of project definition, a concept is a construct of thought that is meant to solve a problem or satisfy specific needs. It should be of such a nature that several different concepts might be identified as solutions to the same problem. Further, in each specific case, all concepts ought to be real alternatives in the sense that they are mutually exclusive. This would imply that they should have certain common features that make them suitable as solutions to the same problem. Finally, the quality of being principled means that the concepts are not just variations of a particular solution" (Samset & Volden, 2012, p. 59). A number of concepts might be identified, then one chosen, and it is this which forms the basis of the investment case and ultimately the project.

As Stamatiadis, Kirk, Hartman, and Pigman (2010) describe regarding roadway projects, the definition and clarification of the initial project concept is the cornerstone of the project and is used to significantly contain the cost and impact of a project, developed with a clear understanding of the objectives of the project and designed to address those objectives while "balancing project factors and elements." It is important to start with the problem and related needs and objectives to consider the concept, rather than what is often the case, choosing a concept and just staying with that (Samset & Volden, 2012, p. 62, discussing the work of Minken).

A similar stance is taken by Patanakul and Shenhar (2012), who discuss project strategy by defining the "why" of a project as the objective then establishing the strategic concept, before moving onto the "what" (the definition of the product and success/failure criteria) followed by the "how" (i.e., the project definition).

This idea of the "project concept" can be applied generically for all types of projects. It is important for small projects as much as for large projects (Collins et al., 2017). In IT, Rosen (2004) discusses the first phase of the project life cycle which she calls the "Project Concept;" however, here there is loose discussion of identifying an idea and presenting it to management to be reviewed and approved, then analyzing the idea to determine if it is viable. Rather, the need should be identified before the concept of the solution to those needs.

Gil, Tommelein, and Schruben (2006) point out the dangers of moving beyond the concept stage and going into a design phase too early in situations of uncertainty. They show that while early commitments on design decision making increase the upside risk of speeding up delivery if external events do not materialize, they increase the downside risk of causing design rework and losing process predictability if these events do materialize. They show that moderate design postponement avoids the risk of lateness because it reduces expected variability in design.

Clearly, the clarity of the concept definition, and the development of that in the next stages, is important for the performance of the project. Son and Kim (2015), for example, looked at empirical evidence of green building projects and showed their performance was highly dependent on the quality of definition in the pre-project planning phase.

5.2 Conceptual Appraisal and Alternatives Analysis

Having defined what we mean by a concept, once an organization has established the needs or problems that need to be resolved, the various project concepts that could answer those needs have to be identified, and one chosen and understood. This statement is simplistic, and in looking at concepts it must be remembered that humans only have limited insight into the possibilities due to cognitive limitations and bounded rationality, and that the future is not perfectly predictable. Indeed, some authors in this situation describe the attempt to define project goals themselves as "futile" (Engwall, 2002), so the attempt to analyze concepts to satisfy those goals would be even more futile. However, generally it is considered that planning should select project concepts against the recognized needs of the organization.

The importance of such ex-ante evaluation might seem clear, but Samset and Christensen (2017) look at various logical ways of thinking about these situated, complex projects (instrumental, institutional, environmental, and contingency logic) which helps to clarify some of the issues around this analysis. In looking at a number of projects, they identify that only around a quarter had clear, well-thought-through analyses at the start.

Samset states that "there are no commonly agreed guidelines for . . . systematic identification and selection of unique and different solution to a problem. Also, there are not a great many studies that offer a systematic inquiry into how this is done in practice, the range of alternative concepts that are identified, and which ones are chosen" (2010, p. 100). He quotes a paper by Minken, Larsen, Braute, Berntsen, and Sunde (2009) (in Norwegian) drawing lessons from the Norwegian quality assurance (QA) system, concluding that (among other conclusions) generally, "alternatives" considered were simply different technical solutions rather than genuinely mutually exclusive concepts, that the tendency was that preferred technical solutions guided the choice of concept rather than vice versa, and that the link between the choice of concept and the essential need to be satisfied was unclear and not explicit.

Samset, Andersen, and Austeng (2014) provide an analysis of a number of concept analysis studies and report empirical evidence that the search for alternative concepts is often, in practice, very restricted (ironically quoting a Norwegian social scientist as saying "a public inquiry commonly results in two alternatives that are almost identical, and a third that for some reason is entirely unfeasible"). This they put down to four factors, the main one being political pre-determination, but also path dependency (alternatives represent a continuation or variant of the current solution), the level of detail in analyses (which were often very detailed and more project-specific rather than facilitating conceptual discussion), and a sectorial focus being too strong. What seemed to be common across the cases was a conceptual analysis that occurred too late in the process. For example, an analysis of transport needs generally, a decision to use a rail solution, then passing the project to the rail authority which then carries out the conceptual analysis despite the choice being a *fait accompli*. This is summarized by Samset and Christensen (2017), who say, "Ex ante evaluation is a broad initial assessment aimed at identifying which alternative will yield the greatest benefit from an intended investment. More commonly, considerable resources are used on detailed planning of a single, specific solution, whereas alternatives are not (or are inadequately) assessed early on. Consequently, there is no adequate basis for concluding that the preferred alternative is the best choice" (p. 2).

The evaluation of a concept and its impact needs to take a broad view of its effects. "The benefit of an ex ante evaluation is principally related to whether one is able to identify the best solution . . . this will be based on estimates of the project's effects" (Samset & Christensen, 2017, p. 2). It is interesting to see how projects are commonly reviewed ex-post (see e.g., Volden & Samset (2017a), based on the USAID then UN/OECD

methodology, where projects are considered in terms of efficiency, effectiveness of other impacts, relevance, sustainability, and socio-economic efficiency. While the first of these is essentially an ex-post criterion, the others need consideration as a concept is mapped against the needs it is trying to address. With ex-ante, though, the considerations of uncertainty and scenario analysis in Section 4 need taking into account as decision makers look to an uncertain future.

Samset (2010) also emphasizes consideration of "the zero option," or the "reference concept," an important idea in many governmental cost benefit analyses (see Section 6.2), assuming that the project is arising out of a desire to achieve some benefit rather than an emergency necessitating the project (see Section 2.3.1). When chosen, the selected concept needs to be appraised in depth. The discussion of Section 4.3 (which we said covered throughout the front end of the project) is relevant here as we consider a project concept that has now been chosen. Samset (2010, p. 161, Figure 16.1) provides an overview of how techniques for concept appraisal fit together, starting with the concept definition based on functional requirements, elaborated by SWOT analysis, strategy analysis, uncertainty mapping (including both downside risk and upside opportunities), and strategic management, into assessment tools such as risk analysis, progress analysis, and cost and profitability estimation, into the essentials of a project plan. These aspects will be studied in more detail once a project concept is selected, and the project defined, and this assessment is discussed in Section 6 below, which covers:

- Scope (and link with strategy);
- Estimating: cost; (including equivalent costs, e.g., technology lock-in); benefits; schedule; through-life cost, all considering optimism bias and strategic underestimation; and risk analysis;
- Use of lessons learned from previous projects;
- Technology;
- Environment and sustainability; and
- The project delivery system.

This will be done with a paucity of data at this stage. However, Williams et al. (2009) consider that this can often be a benefit rather than a hindrance, avoiding "analysis paralysis" and detailed consideration of a few pre-defined concepts.

6. Project Assessment

A main part of the front end is assessing the project concept that has been settled on as part of Section 5. This section will cover the various aspects of this; particularly, the various issues involved in estimating, but also (before that) the scope of the project and its link with strategy, then following estimation, learning lessons from previous projects, technology and environmental/sustainability assessment, and consideration of the various project delivery systems available.

6.1 Scope

Defining the scope of a project is clearly key to defining what that project is to consist of. Here, the key link is to the strategy of the organization and the purpose of doing the project, as described in Section 3.1. The scope may not be fully defined at this point in the life cycle, so parametric methods might be useful (see the work of Holmlin, 2016). But it is important to have as full a definition as possible: Fageha and Aibinu (2014) discuss the importance of a complete project scope definition during the project front end, as well as identifying and prioritizing project scope definition elements at the pre-project planning stage (this was in the context of public buildings in Saudi Arabia). Failing to do so can be an important cause of problems later in the project: Jergeas (2008), in his well-known analysis of Alberta oil sands projects, points to "incomplete scope definition or inadequate front-end loading and poorly completed front-end deliverables" as a significant cause of later-phase problems.

The definition of the scope develops during the course of the front end. Cost estimates early in the front end might be inappropriate if the scope has expanded during the definition activity of the front end. Such "scope creep," due to change either in the technical specification of projects or in budgeting classification, and with exogenous shocks in the wider economic and security environment, was felt to be a key reason for underestimation of the initial budget for the London 2012 Olympics (Jennings, 2012).

6.2 Estimating

The main element of the project assessment is estimating the project as far as it has been defined, particularly the likely time and cost. Estimating sets the level by which expectations of the project are compared, with the final verdict of over/under budget (whether time or cost), of course, depending upon how that budget has been set. But it also helps in decision making. For example, the General Accounting Office (GAO) (Fleming, 2013) describes how "project estimates could be improved to better inform future decisions" (by using the GAO's "best practice"). Underestimating costs, of course, can and does lead to projects being selected on the basis of wrong information (Andersen, Samset, & Welde, 2016).

Estimating both costs and benefits is necessary in order to carry out a cost-benefit analysis (CBA). However, a CBA should not be seen as a final statement of the usefulness of a project. Mouter (2017) discusses at length the use of CBA in political decision making, highlighting its obvious benefits—providing a structure for evaluating the positive and negative effects, and putting all monetized costs and benefits into one indicator—but showing how it can be seen to "kill" political debate, and encouraging its use as simply one part of the political discourse. Salling and Pryn (2015) take this further, still within infrastructure problems, and look for multi-criteria analysis, including social and sustainability values, combined with stochastic analysis (including reference-class forecasting—see Section 6.2.7). In cases of mega transport projects, the work of Dimitriou, Ward, and Wright (2013) looks beyond CBA to the use of policy-led, multi-criteria analysis.

Estimating as described here is a combination of bottom-up estimation (such as using a work breakdown structure) (Winn, 2007) and parametric methods (see, for example, Brunsman, Robson, & Gransberg, 2008, on estimating environmental remediation projects). Both methods need to learn from project to project. Miłosz and Borys (2011), for example, show that parametric models that are unaltered are insufficient for proper software effort estimation, so they describe an evolving system where experience is transformed into knowledge, which can be used in following software projects.

This section will cover the main areas for estimating: cost, benefits, schedule, and through-life costs, and will then look at some of the issues, optimism bias, strategic underestimation, and the idea of reference-class forecasting. These will then be brought together in a section on risk analysis.

6.2.1 Cost-Estimating Methods

Atkins, Davies, and Kidney Bishop (2017), in an Institute for Government report, give ample evidence within recent UK public projects that costs are routinely underestimated. They point to three causes: the typical appearance of strategic misrepresentation and optimism bias, but also add "anchoring and adjustment" (Kahneman, 2011) and the difficulty that people feel adjusting away from an initial estimate (remembering, as in Section 6.2, that costs tend to be particularly underestimated at the start of the front end). Many projects, both public and private, overrun their budget. And, to some extent, the reasons for this are being placed on behavioral issues during the front end (Legaca, Radujković, & Šimac, 2014).

Parametric estimating techniques have been established in many areas. Such methods for costing are discussed in Kwak and Watson (2005) and, for construction, Sae-Hyun, Moonseo, and Hyun-Soo (2010), and Wang, Bilozerov, Dzeng, Hsiao, and Wang (2017). Dursun and Stoy (2016) go further and provide mathematical techniques for estimating conceptual costs of building projects at the conceptual phase.

Public projects are prone to wider influences in the project front end, with estimation particularly difficult in software projects. Doloi (2011) shows the roles political and legislative factors play in this phase in public projects, as the need to include input from contractors, land developers, consultants, financiers, and the project manager. The importance of statutory compliance and environmental issues is shown. He shows the development of costs as the front end proceeds, such as the increasing use of "provisional sums" (i.e., specific contingency funds set aside to cover lack of certainty as the project goes out to tender).

This lack of certainty is, of course, a key issue in estimation. Risks need to be evaluated, and a contingency placed upon the cost (i.e., an increase in budget is needed to increase the confidence in achieving that budget (see Touran, 2010, and Thal, Cook, & White, 2010). These will be explored more fully in Section 6.2.7 below. Torp and Klakegg (2016) describe some of the current methods for estimating in the face of uncertainty (based on a particularly uncertain project: decommissioning a nuclear power plant), and find them satisfactory, particularly using the Successive Principle (see Lichtenberg, 2000).

Samset and Volden (2012) describe how the estimates (particularly cost) are developed during the front end. They point out that the level of cost overrun considered at the end of the project is "often only the tip of the iceberg. In innumerable cases, the budget increase in the front-end phase, from the first cost estimate to the adopted budget, is much greater in relative terms. An interesting observation is that, for projects in general, the initial cost estimate, almost without exception, is lower, not higher than what is eventually decided for the final budget." Indeed, this is one of Samset and Volden's (2016) "ten paradoxes," that the focus is on the

final cost estimate (the budget), while early cost estimates are overlooked. An unrealistically low initial cost estimate will increase the chances of the project idea being considered/adopted, and subsequently influence strategic success.

This point is also made and evidenced by Welde and Odeck (2017). Some of the causes will be considered in the sections on optimism bias (6.2.5) and strategic misrepresentation (6.2.6) below. Legaca et al. (2014) point to these same underlying reasons why costs, benefits, and time forecasts, particularly for more complex projects, are systematically over-optimistic in the planning phase in comparison to less-complex projects, using experiences of European infrastructure projects as an example. But initially low estimates that are increased significantly during the front end are so common that this is now described as "normalization of deviation" (Pinto & Slevin, 2006).

This variation during the front end is important for the concept of "lock-in." Costs are considered at the formal decision to execute a project, but often, the actual decision to execute (e.g., build a piece of infrastructure) precedes the formal decision (see Cantarelli, Flyvbjerg, van Wee, & Molin, 2010), so decisions are made on earlier, lower, cost estimates. And this phenomenon of "lock-in," which Cantarelli et al. (2010) describe as "the escalating commitment of decision-makers" can occur both at the decision-making level (before the decision to build) and at the project level (after the decision to build). Sunk costs, the need for justification, escalating commitment, and inflexibility and the closure of alternatives can all be seen as indicators of "lock-in" during the front end, and can lead to sub-optimal—that is, higher-cost—decisions.

Of the various ways that upstream decision makers can affect the downstream performance of projects, such as choices about ways of financing the project, or procurement routes to be used (Morris & Hough, 1987), arguably the most important will be the forms of technology to be used. In some project sectors, the choice of technology is not singularly critical (e.g., the majority of smaller-scale construction projects). But in others (e.g., software platforms), it can be crucial. This becomes "super critical" when a project uses third-party technology that has an ongoing need for support. For example, bespoke organizational software systems floundered when they were based on Microsoft's XP operating system, which Microsoft decided to eventually no longer support. This risk of locked-in technology can become fatal for projects, as was the case with the UK's Ministry of Defence when, in 2010, it took the decision to scrap the remaining Nimrod MRA4 aircraft as the airframes were built to house technology that had dramatically altered in the 14 years since the order was originally placed (Anderson, 2011).

Liu and Zhu (2007) follow this theme by looking at critical factors for effective cost estimation during each project phase of a conventional construction project, suggesting that the way that estimates are made should change, since as cost estimating progresses, programmability and measurability increase. Similarly, Uppal (2009) discusses different methods for the different construction phases as discussed in Section 1.1.

In developing bottom-up estimates, estimation needs to remember not only the overall cost, but also cash flow, both in the individual project (Qingbin, Hastak, & Halpin (2010), or in a more sophisticated analysis (González Jiménez & Blanco Pascual, 2008), and in the portfolio (Mohammad Mahdi, AbouRizk, & Heravi, 2017). The indirect costs need to be included (Littau, Jujagiri, & Adlbrecht, 2010), and the correlations between cost items are an important issue (Firouzi, Wei, & Chun-Qing, 2016; Moret & Einstein, 2012b). Such estimates, of course, require a reliable database of the cost elements, and often such databases are not available. However, Boeschoten (2003) describes one database in the UK that is publicly available.

Historical information is important for base estimates. Constructing databases needs contextual information (Kiziltas & Akinci, 2009). The development of Building Information Modeling (BIM) will help this and indeed make decision making easier for building projects (Lu, Won, & Cheng, 2016). However, an analysis by Aibinu and Pasco (2008) point out that historical benchmarking needs careful analysis and database updating. This latter analysis interestingly looks at estimates just before a tender is put out (which is the "end" of the front end), and found that estimates tended to be overly generous, particularly for smaller projects (although Jørgensen, Halkjelsvik, & Kitchenham [2012] suggest that the statistical analysis of the relationship between size and cost estimation error needs careful thought).

Looking at the history of projects shows that cost overruns frequently occur, although that does not definitively imply that cost underestimation was a reason. Looking, for example, at the literature on oil and gas megaprojects shows that complex interactions between project characteristics, people, technology, structure, and culture all contribute to cost overruns (indeed, the paper by Olaniran et al. even suggests using chaos theory to explain how cost overruns arise) (Olaniran, Love, Edwards, Olatunji, & Matthews, 2015; see also Merrow, 2011).

The definition of the "end" of the front end is important. Halawa et al. (2013), look at Swedish infrastructure projects, and claim that most cost overruns occur in the planning stages up to the final design, and are related to design changes and increases in the amount of inputs needed because of technical and administrative problems. These would be assumed to have occurred after the project is sanctioned and thus are after the front end concludes and, indeed, appear to be after the start of the "execution" phase.

But it is clear that underestimation of costs is very frequent (Andersen et al., 2016), and Sections 6.2.5 and 6.2.6 outline some of the reasons.

6.2.2 Benefits-Estimating Methods (Including "Wider Economic Benefits")

It is reasonable to expect that a project is carried out in order to achieve some end or some type of benefit. Section 3 discussed the purpose of the project in achieving those ends or benefits, and the concept in Section 5 was chosen to satisfy that purpose. The "success" of the project was defined in Section 3.2 (simplistically) as the extent to which those ends or benefits were achieved. This all assumes that we can look at the benefits achieved, ideally quantify the extent to which these have been achieved, and see whether our project has been a success.

Zwikael and Smyrk give definitions for concepts such as benefits, target outcome, and outputs as well as explain the relationship between them. A benefit here is described as "a 'flow of value' that is triggered by the realization of a target outcome. A target outcome is defined as a desired, measurable end-effect that arises when the outputs from a project are utilized by certain stakeholders. We define outputs as the artefacts that are produced from the work of the project" (2012, S10).

Chih and Zwikael (2015) develop a framework of project target benefit formulation for the public sector, where benefits are often dynamic and have different meanings for various stakeholders. They look at whether target benefits are relevant (to the organization), are measurable, achievable, and specific (i.e., SMART), and also comprehensive in category of benefits and timescale. Samset and Volden (2016) differentiate absolute and relative target benefits indicators when setting objectives and assessing project success.

As well as in costs, benefit estimation and target planning is subject to biases, and particularly the effects of optimism bias and strategic misrepresentation, and these are discussed in Sections 6.2.5 and 6.2.6, respectively.

In practice, many benefits can only be quantified with difficulty, and guidance on how to identify and quantify them seems to not be consistent. An example recently published is Atkins et al. (2017), which looks at inconsistent practice in measuring costs and benefits of UK infrastructure projects. There is ongoing work within PMI to address these issues.

6.2.3 Schedule-Estimating Methods

The principles of schedule-estimating methods are similar to those of cost-estimating methods (Section 6.2.2), except that bottom-up time estimates have to consider activity predecessor/successor relationships rather than simply adding costs up.

Past data are useful where projects or individual activities are repetitive (Baqerin, Shafahi, & Kashani, 2016). At the start of the front end, often parametric estimation techniques (for cost and time) are needed, and Kwak and Watson (2005) cite examples for technology projects such as the military. "Learning" or "reasoning" tools to estimate are becoming more common, and RunZhi, Sangwon, ChangTaek, and Yongwoon (2016) give an example of case-based reasoning to provide an accurate estimate of construction duration with limited information available in the preliminary stage. Uncertainty makes calculations more difficult, and Barraza (2011) gives an example of probability schedule estimating using Monte Carlo methods.

Time and cost are inextricably linked, and estimates need to consider these together. Papers such as Vandevoorde and Vanhoucke (2006); Kim, Kang, and Hwang (2012); and Balouka, Cohen, and Shtub (2016) look at these together and consider the triple-constraint trade-off. This is particularly so when considering time-cost trade-offs and trying to optimize. Sousa, Almeida, and Dias (2014), for example, use regression curves but also engineering judgment; Cho and Hastak (2013) look at estimating in fast-track projects.

Maravas and Pantouvakis (2012) and Moussa, Ruwanpura, and Jergeas (2009) look at how the relationship between cost and schedule also affects cash flow, the latter showing the benefits of integrating time networks with other types of networks to overcome modeling challenges in measuring project cost and schedule risks, again making use of simulation.

6.2.4 Through-Life Cost Considerations

Where the project involves an initial capital investment in an asset or a change, whose value will be realized over a period of time, then cost and benefits need to be considered through-life, and it is particularly important to do this in the front end of the project.

> Cost estimates prepared in the early stages of a project allow a client to evaluate tenders, secure funding, and/or perform a cost-benefit analysis. . . . When a project is a commercial asset, the initial capital investment to deliver it must be balanced with the cost of maintenance and operations over its lifetime to ensure it remains profitable, and planned returns on investment are achievable. Thus, decisions made during the formative stages of a project carry far-reaching economic consequences and can seal its financial fate. Effective cost planning, therefore, relates design of buildings to their cost, potential scope changes, quality, utility, appearance, as well as other risks that might affect the delivery of the project on time and an agreed-on budget. (Ahiaga-Dagbui, Love, Smith, & Ackermann, 2017, p. 89)

While whole-life cost appraisal is important to be able to make a judgment about the project, it is whole life performance that needs to be considered, and Sung Ho (2009) looks at different critical success factors and delivery mechanisms with a whole-life performance perspective. The greatest benefit of life cycle costing comes from the initiation phase of construction projects. Schneiderova Heralova (2014) summarizes major issues of life cycle costing, and presents the most frequently used methods of cost calculating as used in public works contracts.

6.2.5 Optimism Bias

It is well known that a prime cause of mis-estimation is the human tendency to be overly optimistic, as famously discussed (in generality) in Kahneman's work (2011) and applied to projects particularly by Flyvbjerg (2006). Optimism bias has clearly been shown to be a factor both in underestimating costs, and also in overestimating likely benefits of major projects, with Flyvbjerg, Bruzelius, and Rothengatter (2003) being the most well-known exposition (of optimism bias, and of strategic misrepresentation; see Section 6.2.6). Mentions of optimism bias are frequent both in analyses of cost overruns (Jergeas, 2008, for example, mentions "overly optimistic original cost estimates" in his analysis), and in advice on how to view estimates in project governance (e.g., in governments, HM Treasury, 2013; State of New South Wales – Department of Finance Services and Innovation, 2015). The existence of optimism bias, however, has been known for a considerable time, and it was observing this in the World Bank that initiated Hirschmann's work (1967), and more recently, Hirschman (2015) where he argues that this "over-optimism is in fact fortunate because decision-makers also underestimate their own creativity and ability to overcome the problems, difficulties, challenges, and obstacles they encounter while implementing the project" (in Ika's 2017 work on developments of Hirschmann's ideas).

Kutsch, Maylor, Weyer, and Lupson (2011) confirm the extent and impact of optimism bias in initial project planning and the ongoing or sustained false optimism beyond the planning phase of projects, and look at qualitative evidence for five psychological factors causing optimism bias: motivated reasoning, outcome attribution, egocentricity bias, paradox of dispositional optimism, and possibly, outcome desirability. Son and Rojas (2011) also note the interaction between a manager's optimism bias and organizational dynamics.

While these papers all describe optimism bias as unconscious, Bertisen and Davis (2008) show that the situation is not improving (so learning is not happening), and argue that the persistence of bias is instead intentional and rational, "driven by a persistent excess demand for project finance, with engineering consultants acting rationally, in implicit agreement with project sponsors, to underestimate capital costs." Project sponsors are aware that there is an excess demand for finance, which requires them to underrepresent their project costs when presenting their projects to financiers. Consultants are aggressive in cost estimation to support project sponsors' wishes. Since financiers lack the resources to perform due diligence to the extent required to uncover this downward bias, the bias continues, particularly for smaller rather than larger projects (larger projects being subject to more scrutiny by banks and similar organizations).

Sample (2015) points out that the source of planning fallacy is a bias in decision making originating from human intuition. It notes that the UK's government has created a "behavioral insights team" (BIT; also known as the nudge unit) for the purpose of infusing practical applications of behavioral economics into public policy debates and issues, with a similar initiative in the United States.

6.2.6 Strategic Misrepresentation

The second cause of cost underestimation (with related benefits overestimation assumed throughout this section) identified by Flyvbjerg (Flyvbjerg, 2006; Flyvbjerg et al., 2003) is known as "strategic misrepresentation;" that is, the deliberate underestimation of costs in order to get the project approved. "The terms *strategic misrepresentation* and *manipulation of information* are used to refer to planned and systematic distortion or misstatement of facts in budgeting and planning systems" (Dalcher, 2016, p. 4).

This is not an entirely uncontested theory. Conclusive evidence of this can be difficult to find (Andersen et al., 2016). More fundamentally, Osland and Strand look at the theory and find shortcomings. They say, "Methodologically, the research has not the design necessary for validating the conclusion of 'the survival of the unfittest.' Theoretically, the framework does not offer any variation on the institutional variable nor when it comes to variation in planners (actors) motives and rationality" (2010, p. 77). They offer a broader theoretical framework and apply it to Norwegian transport planning, bringing the idea of strategic misrepresentation (by planners) into question.

Andersen et al. (2016) look at the evidence in a sample, again of Norwegian projects, and find some evidence of strategic misrepresentation (among a range of reasons for cost underestimation), and discuss whether a higher initial estimate in those projects would indeed have led to project cancellation.

Again, the answer could lie around the external view and increased oversight. Klakegg et al. claim that "Lying and deceiving in the budgeting process are reduced due to use of external control and increased transparency in Norway and the UK. In the Netherlands, extensive participation gives more transparency directly and potential for early identification of conflicts" (2016, p. 293).

However, the "outside view" might not understand some of the intricacies and context of the project. Koch (2012) suggests that the outside view of reference-class forecast (discussed in the next section), which draws on an understanding of strategic misrepresentation (and optimism bias), should be combined with the inside approaches appreciating the socio-technical content.

6.2.7 Reference-Class Forecasting (RCF)

There are a number of ways that the issue of optimism bias can be approached (see, for example, Sample, 2015). One way that is proposed is "reference-class forecasting," which "achieves accuracy by basing forecasts on actual performance in a reference class of comparable projects and thereby bypassing both optimism bias and strategic misrepresentation" (Flyvbjerg, 2006, p. 5). In this method, a reference class of projects is analyzed, so that a standard multiplier can be placed on initial estimates (Prieto, 2013, gives an introduction to optimism bias or the "planning fallacy," and to reference-class forecasting).

Rather than offer a full literature survey here, a literature survey has already been done recently by Prater et al. who conclude:

> Optimism bias proved to be widely accepted as a major cause of unrealistic scheduling for projects, and there is a common understanding as to what it is and the effects that it has on original baseline schedules. Based upon this review, the most recommended mitigation method is Flyvbjerg's "reference class," which has been developed based upon Kahneman's "Outside View." (2017)

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Both of these mitigation techniques are based upon using an independent third party to review the estimate. However, within the papers reviewed, apart from the engineering projects, there has been no experimental and statistically validated research into the effectiveness of this method. The majority of authors who have published on this topic are based in Europe (Prater et al., 2017). A key difference they point out is that "unlike reference class forecasting, the outside view does not apply a standard multiplier depending upon the type of project, but recommends that the project team review similar classes of project to use as the basis to commence their estimation upon" (Prater et al., 2017, p. 380).

Batselier and Vanhoucke (2016) compare the use of RCF with baseline estimates, Monte Carlo simulation, and earned value management in forecasting. It confirms that the RCF technique is the most user friendly, as it does not require a great deal of detailed information or extensive calculations. In addition, they say that it surpasses all the traditional techniques in accuracy, stability, and timeliness. However, RCF only outperforms the other techniques when the degree of similarity between the considered project and the projects in the reference class is sufficiently high. However, they say that is relatively difficult to correctly implement RFC in practice because of its strong dependence on the selected reference class.

Flyvbjerg et al. (2016) describe a study of 25 road projects in Hong Kong to test the feasibility of using RCF. They suggest improving forecasts by: (1) de-biasing early estimates, (2) explicitly considering the risk appetite of decision makers, and (3) safeguarding public funding allocation by balancing exceedance and under-utilization of project budgets.

It needs to be considered when to apply RCF. "RCF has been so far used to address estimation bias in early project development before design is completed and before all risks are accounted for. . . In this paper, however, it is used to produce a forecast of the final project cost based on the contract sum" (Bayram & Al-Jibouri, 2016, p. 1).

It should be noted that RCF has gained significant traction and is now applied as standard in the UK government (HM Treasury, 2013).

6.2.8 Risk Analysis

While the general areas of uncertainty were considered earlier in the front end, toward the end of the front end and before the project proceeds, a more detailed risk assessment can be carried out based on the knowledge that has been considered. Projects being by nature one-off means that while some uncertainties can be understood from the data on previous projects ("aleatoric" uncertainties), unknowns about the future, new initiatives, and new technology and bounded human rationality means that there is significant "epistemic" uncertainty (Williams & Samset, 2010). Indeed, even in apparently repeat-type projects, the uncertainty can be largely epistemic (for example, Ahiaga-Dagbui, Love, Whyte, & Boateng, 2017, discuss the problems of costing UK North Sea Oil and gas offshore decommissioning projects, and note the inability to estimate reliably the volume and cost of work to be undertaken, exacerbated by a supply chain with limited experience in such projects). The need for such analysis is true for both waterfall or agile projects (Choles Arvilla, 2014).

There is a wealth of literature in this area, including some recent useful literature surveys:

- Thomé, Scavarda, Scavarda, and Thomé (2016) look at the relationship between the ideas of complexity, uncertainty, risk, and resilience, referring to both the supply chain management and project management literatures, using 22 literature reviews as its basis.
- Zhang (2011) looks at the literature on project risk dividing it by two ideas of "risk as an objective fact" and "risk as a subjective construction."

- Sanchez-Cazorla et al. (2016) provide a literature review of risk management in megaprojects and classify the risks studied in the literature into nine specific categories of risks (design, legal and/or political, contractual, construction, operation/maintenance risks, labor, customer/user/society, financial/economic, force majeure), which can be a useful basis for the initial identification phase of risk analysis.

Risk analysis is a very well-established part of the project front end. However, it has to be said that the evidence is not clear as to how useful it is and why, and authors such as Bakker (2010); de Bakker, Boonstra, and Wortmann (2011); and Kutsch and Hall (2009) consider critically how these exercises operate and the possible logical and philosophical flaws.

A key element is risk analysis is distinguishing "operational" risks from "strategic" risks. Krane, Rolstadås, and Olsson (2010) show how risk registers will often concentrate on operational objectives (i.e., those concerning the project outputs/results) rather than strategic objectives (concerning the project goal and purpose), even though evidence shows clearly the latter to be important. Here again, the deliverability of the project can take attention away from the benefits that the project is seeking to achieve. Krane, Olsson, and Rolstadås (2012) have a similar finding, differentiating between risk management by or for the project management team (which focuses on project short-term survival or project success toward handover to the customer), rather than by or for the project owner (for whom strategic success should be more important). Browning (2014) suggests the need (for the owner) to model value, risk, and opportunity all together. Zwikael, Pathak, Singh, and Ahmed (2014) draw out similar lessons distinguishing the degree of planning needed in high-/low-risk projects. The most frequently analyzed risks in the literature on megaprojects are risks associated with the operational "triple constraint" (those that result in cost overrun, time delays, and lower project performance) (Sanchez-Cazorla et al., 2016).

Risk analysis generally follows a clear (but cyclic) process: identification, evaluation of individual risks, then analysis of the overall risk picture.

First comes risk identification, which is a fairly well-known activity. Recent publications to further this area include:

- Tiendung, Caldas, Gibson, and Thole (2009), who propose a method to proactively identify risk sources based on the analysis of the project scope (including a mechanism to evaluate quantitatively the scope elements' level of definition) to help determine potential levels of risk;
- Zeynalian, Trigunarsyah, and Ronagh (2012), who propose a method to consider potential risks that might occur over the entire life cycle of the project, including technical and managerial failure risks;
- Boateng, Chen, and Ogunlana (2015), who discuss megaprojects;
- Goh, Abdul-Rahman, and Abdul Samad (2013), who discuss workshops; and
- Xiang, Zhou, Zhou, and Ye (2012), who use asymmetric information theory. This is particularly difficult in widely dispersed (Regev, Shtub, & Ben-Haim, 2006) and international projects (Wong, Unsal, Taylor, & Levitt, 2010), and has to consider both upside and downside risks (Kirkland, 2013).

In this activity, discourse and interrelationships between stakeholders is key (Van Os, Van Berkel, De Gilder, Van Dyck, & Groenewegen, 2015). This is firstly true within the organization: Thamhain (2013) shows empirically that risk does not affect all projects equally but depends on the effectiveness of collective managerial actions dealing with specific contingencies, and discusses why some organizations are more successful in detecting risks early in the project life cycle, and in decoupling risk factors from work processes before they impact project performance. Govan and Damnjanovic (2016) use a project causal network to look at the risks across an organization. But, of course, this is equally true across project stakeholders more widely, and Osipova and Eriksson (2011) show how the type of project delivery and degree of partnering help the process of risk analysis.

In megaprojects and large, international projects, the risks can become much more ill-defined and often move into the socio-political space. Vereen et al. (2016), for example, describe risk considerations as most impactful on international projects, discussing risks associated with politics, geography, economy, environment, regulations, security, and culture. Liu, Zhu, Wang, and Huan (2016) consider this area of non-technical risk and develop what they describe as a Social Stability Risk Assessment.

The second step is to quantify the risks, either by using expert judgment or past data (e.g., Choi & Mahadevan, 2008). In evaluating the whole risk profile, it is important to remember that risks are not self-contained, but will often be interrelated or come in sets or systems (Qazi et al., 2016; Williams, 2017; Zhang, 2016). A well-known and well-used stepwise analytical method is Lichtenberg's Successive Principle (Lichtenberg, 2000), gradually refining estimates of uncertainty in areas most impactful or most uncertain. But a wide variety of methods has become available for risk assessment and evaluation method during front end, and Burcar Dunovic, Radujkovic, and Vukomanovic (2016), for example, describe various multi-criteria analysis methods used for risk assessment such as fuzzy analysis, fuzzy cognitive maps, extended fuzzy cognitive maps, and analytical network process.

The objectives of the project cannot be treated independently, and it is important to analyze schedule risk (see Section 6.2.3) along with time planning (see Dikmen, Birgonul, Tah, & Ozer, 2012; Khamooshi & Cioffi, 2013; Pawan & Lorterapong, 2016; Schatteman, Herroelen, Van de Vonder, & Boone, 2008), as these affect each other and indeed can sometimes to some extent be traded off against each other. Indeed, it would be conceptually advantageous to consider schedule, cost, and quality all together in some integrated fashion (Sarigiannidis & Chatzoglou, 2014; Zeynalian, Trigunarsyah, & Ronagh, 2013). Imbeah and Guikema (2009), for example, give a combined risk tool for cost, schedule, and quality risks together.

These analyses are by no means simple, as the combinations of risks will produce an uncertainty system that is complex and emergent. This is particularly so as there will be humans in the project system causing complexity, and human interaction within the project will compound with the risk interdependencies (Williams, 2017).

Finally, Teller, Kock, and Gemünden (2014) note that the risks in all of a portfolio ought to be considered as a whole, as the strategic risk of one project needs to be considered in the light of the risks coming from the entire portfolio.

6.3 Lessons Learned

It seems axiomatic that taking advantage of lessons learned from previous projects should play an important part in the development of future projects. There has been considerable literature on the collection of "lessons learned," such as Williams, (2008); Duffield and Whitty, (2015); and Hartmann and Dorée (2015). However, these do not appear in a literature search on the "front end," perhaps because it is assumed that such lessons would be applied then. One paper that does appear is that of McClory et al. (2017), who conceptualize the lessons-learned process and explain how learning goals defined at all organizational levels should form part of the business case, project benefits, and risk management processes.

6.4 Technology Assessment

As already noted in 6.2.1, an important area to assess before fully defining the project is the technology to be used. This covers a range of factors:

The major area is the maturity of the technology. Key to this is the standardizing of "Technology Readiness Levels (TRL)" (see Towery, Machek, & Thomas, 2017, particularly applied to transportation). Clearly, the less ready the technology, the higher the risk to the concept being successfully developed.

This is one element, but not the only element, by which the appropriateness and efficiency of different technological solutions can be compared. Cost, quality, availability, security, and obsolescence are also important in the considerations (so perhaps, a technology that is unproven needs to be compared with a technology that will be obsolete and unsupported by the end of the life of an asset being developed).

Many projects require a mix of technologies and these will be at different levels of readiness. Özmen (2014) poses some questions (used in Shell Global Solutions) to ask during technology selection, such as:

> If technologies are sourced from different licensors, will they match at the interfaces? If they were designed to different standards or philosophies, there is the risk of plant underperformance, delays and rework costs. However, there can also be benefits to selecting a team of licensors because they all provide knowledge and insights that can be very beneficial to owners. Another question to consider is whether to install new technologies that have not been commercialized at an industrial scale. These may provide specific benefits, but, if they are not proven and de-risked, they could increase the completion risk and, therefore, the cost of finance. (p. 3)

In addition, the effect on the economy and society needs to be assessed, bringing in the aspects of other stakeholders considered below.

6.5 Environmental Assessment and Sustainability

A key project success criterion that is becoming viewed as increasingly important is that of sustainability. Traditional project success criteria (see Section 3.2) focus on short-term and operational project outputs. Issues about stakeholders are only treated superficially, but including stakeholder management within sustainable development would imply a "paradigm shift in the underpinning values" (Eskerod & Huemann, 2013). The idea of "sustainable development (SD) envisions business and their projects to deliver benefits to a broad group of stakeholders. . . . Given the benefits focus of SD, benefits realization helps to understand how SD can be integrated in the management of projects, linking it to strategy" (Keeys & Huemann, 2017, p. 1196). They define SD as:

> Human wellbeing is at the centre of SD as a societal concern for a healthy and productive life in harmony with nature (UNCED, 1992) in the short, medium and long term (WCED, 1987). Sustainable development is a process that addresses holistically the integrated dimensions of economic growth, environmental safeguards and societal wellbeing of all development activities, commercial and non-commercial and which incorporates values of participation, transparency and equity. (Keeys & Huemann, 2017, p. 1197)

They describe an emergent, learning approach to bring stakeholders' views of sustainability benefits into the program. The principles of sustainable development can transcend both short-term needs and long-term responsibility, which Herazo, Lizarralde, and Paquin (2012) claim helps align strategic and tactical plans.

The literature in this area is considerable, covering both social and environmental issues.

On environmental issues, Aarseth, Ahola, Aaltonen, Økland, and Andersen (2017) provide a useful literature survey. Kang, Kim, Son, Lee, and Limsawasd (2013) show that you need more front-end planning for "green" projects. Indicators are important, and Laedre, Haavaldsen, Bohne, Kallaos, and Lohne (2015) and Shen, Wu, and Zhang (2011) look at key environmental assessment indications. Hongping (2017); Hueskes, Verhoest, and Block, (2017); and Zhang, Bao, Wang, and Skitmore (2014) also look at environmental assessment. Strategic environmental assessments (SEA) are a useful tool for banks to manage environmental risks and inform lending decisions (Banhalmi-Zakar & Larsen, 2015). Xia, Skitmore, Wu, and Chen (2014) describe how to define specify sustainability requirements to potential contractors.

Social sustainability considerations are clearly important (Valdes-Vasquez & Klotz, 2012). Decommissioning projects would be a good example, as they are clearly highly dependent on the social implications and dialogue with stakeholders (Christensen, 2011). Rowan and Streather (2011) draw on social impact assessment (SIA) and benefit-sharing literature as well as practical SIA project experience to suggest practical steps to promote the implementation of enhancement measures in projects. While indicators are important, Kivilä, Martinsuo, and Vuorinen (2017) suggest in an infrastructure case study that sustainable project management is implemented using not only indicators but a holistic control package in which control mechanisms are used differently for different sustainability dimensions. In this scheme, internal project control is complemented with sustainable project governance. Mostafa and El-Gohary (2015) have a scheme for looking at the stakeholders in infrastructure projects, considering the benefits and needs of those stakeholders, and trying to achieve social equity. It is important in this to understand the socio-cultural context of all of the stakeholders (Eling & Herstatt, 2017).

Social responsibility is particularly an issue of megaprojects (Samset, 2011; Zhou & Mi, 2017); Williams and Samset (2012) consider an index to cover social responsibility of megaprojects, and Dyer (2017) explores the implementation of megaprojects and their risk associated with social responsibilities (SR) in megaprojects through the lens of cultural sensemaking. A linked subject when considering the economic and social conditions in a country is the Regulatory Impact Assessment (RIA) which is part of considering Official Development Assistance (ODA) loans (Jakupec & Kelly, 2016).

6.6 Project Delivery System

Selecting an appropriate project delivery system is one of the key decisions for a project owner in the front end (as discussed in Saad, Baba, & Amoudi, 2015; Touran, 2008 looking at various systems for construction projects). Mostafavi and Karamouz (2010) describe the basic structure of design-build, or engineering, procurement and construction EPC, etc., and ways of choosing between them. Palacios, Gonzalez, and Alarcón (2014) helpfully describe some generic types of systems used in construction, such as partnering, alliancing, lean project delivery, and relational contracts: traditional/transactional, partnering/transactional with agreements, and alliancing/relational. Special purpose entities or vehicles are particularly useful for megaprojects as a specific delivery mechanism (Sainati, Brookes, & Locatelli, 2017).

Choosing between such mechanisms will involve a number of criteria, such as the following:

- The amount of risk the owner is willing to carry and the level of control required (Touran, 2008). Tran and Molenaar (2015) describe the different risks in different methods. Indeed, the different systems, with different degrees of partnering, facilitate to a greater or lesser extent the ability to carry out risk analysis (Osipova & Eriksson, 2011).

- The complexity of the system being procured. Authors such as Lewis (2009) and Brady (2005) have looked at the procurement of complex product systems, but Roehrich and Lewis (2014) show that while organizations frequently react to increasing systemic complexity with increasing contractual governance complexity, in fact better-performing procurement arrangements show that simplified contractual governance may be more effective to counteract complexity, if this is carried out in combination with relational governance such as interpersonal relationships.
- Whole-life cost appraisal is important to be able to make a judgment about the project. Indeed, whole-life performance is important. Sung Ho (2009) looks at the different critical success factors and different delivery mechanisms offering better whole-life performance.
- Li, Arditi, and Wang (2013) compare the transaction costs involved in different project delivery methods, and look at integrated project delivery methods to minimize these (for the project owner).
- In "alliance"-type delivery systems, part of deciding the project delivery system is identifying and considering the consortium of project partners; Maurer (2010) emphasizes the importance of trust between partners and looks at both outcomes and antecedents of trust; El Asmar, Hanna, and Chul-Ki (2009) describe methods for choosing the optimal alliance team. Hellström et al. (2013) look at the importance of building relationships between key actors and securing their commitment during the early stages of a project (more important for some types of project delivery systems than others).
- If sustainability is important, Mollaoglu-Korkmaz, Swarup, and Riley (2013) show there is a link between the project delivery system, the amount of integration that delivers, and the attainment of sustainability goals; Lenferink et al. (2013) look at integrated design-build-finance-operate (DBFM) delivery mechanisms, suggesting that inclusiveness is increased and they lead to more sustainable infrastructure development because of the life cycle optimization incentives.
- A particular case is that of PPP projects. In this case, there are different government support mechanisms that make the considerations more complicated (Mirzadeh & Birgisson, 2016). Chou and Pramudawardhani (2015) give some advice on key drivers, critical success factors, and risk allocation. Xu et al. (2012) discuss some issues around concession pricing in PPP, with a summary of the literature. Flexible contracts are needed to cope with uncertainty in such projects (Cruz & Marques, 2013). De Schepper, Haezendonck, and Dooms (2015) point out the significant transaction costs before the PPP contract.

Choosing between systems requires consideration of these and many other criteria. Xia, Molenaar, Chan, Skitmore, and Zuo (2013) and Xia, Chan, Molenaar, and Skitmore (2012), for example, in just considering the apparently simple decision of deciding the proportion of design to be provided in the request for proposals in a design-build system, come up with 11 different criteria, including factors such as clarity of project scope, applicability of performance specifications, experience of the various parties, etc. And a choice will need to be made considering all the stakeholders: Zhang, Bao, Wang, and Skitmore (2016), for example, in build-operate-transfer (BOT), consider the optimal project life span and concession period by optimizing over all of the stakeholders.

But the evidence on which to base such decisions is often unclear. Qing, Zhigang, Bo, Peng, and Skitmore (2016) question the reputation of better cost and time performance using the design-build (DB) delivery method, looking at empirical evidence. Kunhee, Hyun Woo, Bae, and Bilbo (2016) look at the evidence when using accelerated contract provisions (ACPs), and show they lead to additional changes. Park and Kwak (2017) consider choosing between design-bid-build (DBB) and design-build (DB), but do not find a clear empirical answer.

7. Setting Up Project Execution

Before moving to full project execution, there are some steps to carry out to ensure everything is prepared. Bradshaw (2008), for example, emphasizes the importance of establishing the project controls organization and functions early in the project life cycle of a large, complex project (such as a construction of a nuclear power plant), including, for example, selection and commitment to a planning and scheduling system. This section will explore three particular areas that need consideration. The first area, looked at only briefly since it is a specialist area, is project finance. The second and third are those areas that realize how the permanent organization passes over the project to the delivery organization; that is, governance (i.e., the oversight by the permanent organization of the delivery), and, where relevant, the contractual mechanism.

7.1 Project Finance

Raising the finance for the project is a specialist area but always of considerable interest (see, for example, "Deals & Developments," 2010). Esty is perhaps the most frequently cited author (2014), and gives an update, although Gatti (2013) is also frequently cited.

There is a general question of how public and private financing is used. Samset and Volden (2012) look into financing mechanisms including public-private partnership, central government funding, public/private loans, soft loans, government-guaranteed funding, and central/local government cost sharing. They look at their features, strengths, and weaknesses under various circumstances, including the issue of providing incentives with or without liability for the users (perverse incentive) so that appropriate methods can be chosen.

One specific area of importance for public projects is the various types of public-private partnership mechanism. The work of Bovis is well known here, and gives good introductions to the area (Bovis, 2012, 2015). Daube, Vollrath, and Alfen (2008) look at choosing between idealized models of PPP financing variants in Germany (specifically "project finance" and "the forfeiting model"), showing the basic characteristics of both models and using economic modeling to choose between them. Key to these types of decision is the idea of how much risk is transferred and the costs of doing so.

7.2 Governance of the Project

As discussed above, it is important to set up a governance structure to oversee the project before it starts. There is a significant amount of literature here. Biesenthal and Wilden (2014) give a literature survey of project governance and analyze it for dominant themes. A similar literature survey on project governance by Joslin and Müller (2015) suggests that we don't fully understand the relationship between project governance and project success.

Public project governance has its own literature: Klakegg, Williams, Magnussen, and Glasspool (2008), and more discussion in Klakegg et al. (2016). Volden and Samset (2017b) compare the Norwegian scheme for quality assurance of major public projects with similar project governance schemes in five other OECD countries, all introduced in the past 20 years. Some differences cover parties and roles, comprehensiveness, flexibility, organization, and whether portfolio management is covered.

Since governance is where the permanent organization has oversight of the "project" organization when setting up the governance strategy, it needs to be oriented to the organization's strategic objectives (Hjelmbrekke, Klakegg, & Lohne, 2017) since the project team, when appointed, will have a much more "efficiency" and a deliverables-focused business model. Indeed, the governance process needs to recognize the benefit of the project to the permanent organization and how that is to be achieved rather than simply the deliverables for which the project manager takes responsibility (Zwikael, Smyrk, & Meredith, 2016), and this is of particular importance in public projects with a more complex socio-political-economic environment within which the project sits. And the processes need to govern not only the project as it is at the time, but also need to be able to pick up early warning signs or "weak signals" of problems (Williams et al., 2012), which might entail some element of "gut feel" as well as recorded metrics.

Continuing their work discussed above, Joslin and Müller (2016) give some rare empirical results (suggesting "control" is not the dominating factor, but rather the stakeholder vs. shareholder orientation). There seems to be potential for drawing more from the general governance literature (Ahola, Ruuska, Artto, & Kujala, 2014). More empirical data are given by Cardenas et al., who look at data on a number of European infrastructure projects and the aspects of the governance structures, covering "the early involvement of the contractor in the design and estimation of costs, procurement procedures, integration of design and construction, the incentives and disincentives regime, risk allocation, contract flexibility, and actions that allow the contracting party to maintain bargaining power during possible renegotiations" (2017, p. 432), and show the effect of these on performance. Here, it was found that the financial/economic setting and institutional setting are important moderating variables. For example, different methods are needed for developing and developed countries, as discussed by Lizarralde, Tomiyoshi, Bourgault, Malo, and Cardosi (2013). Shiferaw et al. (2012) discuss project governance for a particular developing country, Ethiopia.

These questions can be more complex when looking at major multi-firm projects (Ruuska, Ahola, Artto, Locatelli, & Mancini, 2011) in complex, networked structures. For these, more sophisticated governance structures are required that can be flexible and deal with self-regulation and emergence. Miller and Hobbs (2005) re-examine the well-known ~~the~~ International Program in the Management of Engineering and Construction (IMEC) study of 60 large capital projects, and outline the challenges of designing governance regimes for large and megaprojects.

A theoretically grounded approach to governance of IT projects is given by Tiwana (2009), using models of decision-making rights to discuss governance, the fit between governance, and the fit with the various parties and how this affects project performance (see also Lappi & Aaltonen, 2017, looking at governance structures for agile projects in the public sector).

When the projects start, levels below the level of "governance" will be important. For example, Eweje et al. (2012) discuss how information feeding (up) to the project manager is essential to ensure strategic value is created in megaprojects, and in ensuring that the project is aligned with what the project manager perceives to be senior management's view of the drivers for their projects. Such governance mechanisms might be informal, and these are important, just as the formal and contractual are important (Chen & Manley, 2014).

7.3 Contracts

As discussed above, before a project can be handed over to a different organizational entity from the permanent organization for delivery, some sort of legal agreement needs to be made between the parties. In other words, a contract is needed. There are various types of contracts, and a well-known paper by Carty (1995) describes

five different types of construction contracts, namely lump sum, unit price, guaranteed maximum price, cost reimbursable, and construction management.

The key difference between these types of contracts, and a determining factor in the choice between them, is the degree of risk passed to the contractor. Shuibo, Shuaijun, Ying, and Xiaoming (2016) claim that this negatively affects the contractor's cooperative behavior, with the contractor's fairness perception partially mediating the effect. In addition, risk premiums do little to reduce uncooperative behavior.

Palacios et al. (2014) go beyond this simple categorization of contracts. They show how simple types of contracts have not promoted project success, and indeed can be countereffective. They identify three types of relationships that can be used to establish contractual relationships: "(1) traditional/transactional, which operates on risk transference; (2) partnering/transactional with agreements, which promotes a win-win relationship between parties, supported by good faith and agreements outside the original contract; and (3) alliancing/relational, which uses a formal agreement to align objectives and interests of the parties in mutual benefit for the project" (from abstract of paper). This is discussed further in Section 7.3.3 below.

Following this line, Cheung, Yiu, and Chiu (2009) describe how construction-contracting parties can take either a cooperative or aggressive stance in pursuing their goals and give taxonomies for aggressive and cooperative drivers, with the most important cooperative being "openness of contracting parties," while the most important aggressive stance is "goal oriented." They also find that equitable risk allocation in contracts and open discussions of problems can provide a good way forward for negotiation.

As discussed above, public-private partnerships (PPPs) require particular attention as they require long-lasting contracts, generally involving large sunk investments, often with significant uncertainty surrounding the project. Cruz and Marques (2013) describe how this requires contract flexibility, and describe various ways for incorporating contract flexibility into the development of a PPP contract.

For their part, contractors are likely to be carrying out internal reviews of the contract to ensure the amount of risk taken on is appropriate. Derby and Zwikael (2012), for example, discuss the concept of the "pre-project peer review" (PPPR) in mitigating or reducing project risks, particularly prior to committing to a guaranteed maximum price or lump sum contract.

7.3.1 Contractual Incentives

Part of the decision making within the contract setting is the degree to which incentives are useful or helpful, and to incentivize the contractor to deliver the project within the parameters set, or even achieve better performance. It is important to recognize here the discussions on "project success" above, and the distinction throughout between the beneficial gains desired by the permanent organization and the delivery of the project outcomes. Incentivization will only work on those parameters which are incentivized. Generally, these cover project output delivery and not the wider benefits that fall within the permanent organization's strategy.

For a single contractor, Rose and Manley (2010) feature a positively geared procurement approach that promotes the effectiveness of financial incentives. The research results show that if the incentive system is perceived to be fair and is applied to reward exceptional performance and not manipulate, then contractors are more likely to be positively motivated. Pryke and Pearson (2006) use social network analysis for more complex consortia and multi-organizational structures, and look at financial incentives.

There are few empirical data on the effectiveness of such schemes. The study by Kunhee et al. (2016) is one example that looks at empirical data on public transportation projects in California to consider the effect on project schedule of schemes such as incentive/disincentive and cost-plus-time. This showed that both schemes led to more schedule-change and cost-change orders than conventionally contracted projects, and discussed the best combination. Similar unhelpful effects are shown in Choi, Kwak, Pyeon, and Son (2012). Using the same Californian projects, this found that the incentive/disincentive scheme shortened construction duration, but the cost-plus-time strategy produced significant delays, worse than conventionally contracted projects. More evidence is supplied by Suprapto, Bakker, Mooi, and Hertogh (2016), who suggest that it is not the contract type or incentive type on its own that is important, but the moderating effect of owner-contractor collaboration (both relational norms/senior management commitment and teamworking quality). They suggest that projects with a partnering/alliance contract are likely to perform better than those with lump sum and reimbursable contracts, and that projects with incentive contracts are likely to perform better than those without incentives through better owner-contractor collaboration.

Again, public-private partnership (PPP) projects have particular aspects. Liu, Gao, Cheah, and Luo (2016) look at the use of incentive mechanisms to reduce opportunistic behavior by investors. Using principal-agent models, they suggest that there is an optimal level of opportunistic behavior, and they use this to try to find "win-win" schemes. In PPP projects such as build-operate-transfer (BOT), the contract has to cover not just the project outputs (time/cost/quality), but also the quantitative throughput benefits, such as (in transportation projects) the level of traffic. Ashuri, Kashani, Molenaar, Lee, and Lu (2012) use real options theory to help understand the economic risk and calculate appropriate levels for contract parameters such as the minimum revenue guarantee. Hueskes et al. (2017) show the difficulty in formulating social sustainability criteria, and hence, contractual incentives for sustainability. They suggest that this might be why sustainability does not get the attention it should. Indeed, it suggests that the sustainability perspective might be incompatible with a contractual PPP project structure.

7.3.2 Methods for Contractor Selection

After having chosen the type of contract, then, in many circumstances, a contractor needs to be chosen from those tendering for the work.

De Araújo, Alencar, and de Miranda Mota (2017) give a literature survey covering papers over the past 40 years on selecting the right supplier (and evaluating the supplier's performance while the contract is being implemented). This covers a wide range of selection criteria; in particular, quality, cost/price, staff, financial, company management, experience, and time. Clearly, the appropriate choice of criteria depends on the type of project, although they do note that environmental, social, and risk criteria are often missing in research. Watt, Kayis, and Willey also study the literature to identify a suite of representative (principal) tender evaluation and contractor-selection criteria. They find that preferred criteria for evaluating tenders are "those which provide a measure of contractors' ability in terms of their management and technical capability, past experience and performance, reputation, and the proposed method of delivery or technical solution" (2009, p. 250). Watt, Kayis, and Willey (2010) build on the work of Watt et al. (2009) to see which criteria were preferred among a group of 250 engineering project contract management companies, finding that past project performance, technical expertise, and cost were the most important criteria, with organizational experience, workload, and reputation being the least important in their survey.

El Asmar, Lotfallah, Whited, and Hanna (2010) advise on selection of design contractors in public (design-build) contracts where technical aspects of the bid mostly consist of qualitative criteria. Particularly for public projects, decision making has to be transparent and demonstrably clear of bias or influence.

The problem of selecting a contractor is essentially a multi-criteria problem, particularly as public bodies increasingly understand the dangers of choosing a selector on the lowest price, and some literature concentrates on this aspect. San Cristóbal (2012) illustrates the use of two multi-criteria decision-making methods, one the well-known TOPSIS method for selecting a contractor. El-Abbasy, Zayed, Ahmed, Alzraiee, and Abouhamad (2013) use the analytical network process at the pre-bidding stage (see Section 2.3).

7.3.3 Incomplete Contracts

Most long-term contracts for major projects have to be incomplete since they cannot deal explicitly with every possible future occasion but rather leave many aspects to be decided upon later. A key part of the literature here has been the transaction-cost approach (TCA), pointing to the cost savings of not having to write a complete contract (Hart & Moore, 1988; Williamson, 1979). The logic of TCA suggests that parties involved in such complex and emergent projects will write incomplete contracts at the start, which will require renegotiation and completion as the project life cycle progresses. Particularly important to this context is the idea of "relational contracting" to avoid principal-agent issues (Bertelli & Smith, 2009). Researching and implementing this requires a conceptualization of relational quality, which Jelodar et al. (2016) start to do. The degree to which relational contracting works depends upon the nature of the relationship and degree of trust between the parties. An important determinant of success of a contract is whether each party acts in a "perfunctory" or "consummate" manner (Brown, Potoski, & Slyke, 2015, p. 300) (the former conforms to the "letter" of the contract but has small gains for the party but greater losses for the other side; whereas the latter conforms to the spirit of "win-win" and has small losses for the party but greater gains for the other side). Construction is prone to issues such as opportunism because of high complexity, information asymmetry, and asset specificity. Lu et al. (2016) discuss these issues to help set up contracts appropriately.

8. Consolidation and Further Work

This document has looked at a wide body of literature, and from this has described a foundation for what the "front end" of a project is and how it can be approached. This consideration of the front end has recognized its setting and place as the mechanism by which the permanent organization commences the initiative that commissions some temporary endeavor. The various elements of the front-end process have been presented in a structured flow from the genesis of an idea to setting up the project for execution (as demonstrated in Figure 2). Then the literature for the various elements has been described in detail. Without necessarily making dogmatic definitions, the report tries to encompass the various views in the literature. While the authors have strived to create some form of clarity and structure to the issues discussed, it is clear that there are many strands to the front end. In order to better understand these various strands and be able to manage them better, more research is needed.

The definition of what the "front end" actually is, is still not well established, and therefore the idea of an organization "mature" in front-end preparation is unclear, and more research is needed on the effect of the front end on the behavior and outcome of the project.

Referring back to the theoretical "lenses" outlined at the start of this report, the review of the literature conducted suggests the following comments on these lenses:

- *The surrounding environment*. The "front end" is anchored in the surrounding environment. More research is clearly needed, for example, into:
  - How a project derives from the relevant political environments;
  - The understanding of the multiple stakeholders: their incentives, their impact on decisions, the clashes between their differing goals, and coalitions of stakeholders and their impacts on decisions;
  - How analysis supports the entire process: the analysis of root cause as a basis for alignment of needs and objectives, and systematic analysis of the opportunity space as basis for alternative analyses;
  - The relationship with the executive level: clarity of decision-making roles, the effect of high-level anchoring and transparency, and the role of board executives such as the chief financial officer; and
  - The effect of complexity, particularly in mega projects.
- *The intended benefits*. This report has maintained attention on the intended outcomes of the intervention rather than simply delivering the outputs of a defined project. More research is needed on:
  - How to define success criteria of a project; how to understand the more entrepreneurial or creative project with ill-defined goals; goal definition where stakeholder objectives clash;
  - Systematic analysis of the opportunity space as basis for alternatives analyses; and
  - How to maintain attention and set up a project to deliver benefits rather than outputs, and how to write appropriate contracts.
- *Temporariness*. An essential facet of a "project" is that it is temporary or determinate. More exploration and research is needed to understand what the front end is conceptually, where it stops and starts, the relationship of the "front end" with the "project," and the relationship between the permanent organization and the temporary project idea. Clarity of roles is needed during the front end.

Looking at the more practical implications, our paramount objective is to ensure "successful" investments (which might mean, for example, investments in time, effort, and scarce resources that are relevant, economically viable, timely, cost efficient, etc.). To do this, we need to have a conceptually sound front-end process that

understands needs and objectives (including the geographies of the environmental, social, economic, and political landscape) as described above, and a process to find the right type of conceptual solution to address these (rather than, say, reverse engineering to find the needs that are going to be answered by a pre-ordained project with a pre-defined concept). Some of the practical aspects have been addressed in this report, but these include:

- Formalizing and standardizing procedures for analysis and decisions during the early stages (e.g., by using decision gates, analytical tools, estimation procedures, etc.); common analytic formats are needed in both ex-ante and ex-post evaluation to improve decisions based on past experience;
- Having a procedure to explore and reveal the uncertainty space to get the right conceptual solution;
- Understanding how to make decisions on scant information, focusing on major issues first, perhaps restricting the amount of information and the level of details;
- Understanding biases and how to deal with them, including (but not restricted to) optimism bias;
- Concentrating on the strategic benefits to be delivered by the project rather than the immediate delivery objectives of the project; and
- Defining clear roles for the governance of the project when executing.

It is hoped that definition of the front end and the framework of processual elements will facilitate research to put the "front end" on a better conceptual and practical basis.

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Appendix A—List of Journals

#	Journal title	ABS Rating
Accounting		
1	*Accounting Review*	4*
2	*Accounting, Organizations and Society*	4*
3	*Journal of Accounting and Economics*	4*
4	*Journal of Accounting Research*	4*
5	*Contemporary Accounting Research*	4
6	*Review of Accounting Studies*	4
7	*Abacus*	3
8	*Accounting and Business Research*	3
9	*Accounting Forum*	3
10	*Accounting Horizons*	3
11	*Accounting, Auditing and Accountability Journal*	3
12	*Auditing: A Journal of Practice and Theory*	3
13	*Behavioral Research in Accounting*	3
14	*British Accounting Review*	3
15	*British Tax Review*	3
16	*Critical Perspectives on Accounting*	3
17	*European Accounting Review*	3
18	*Financial Accountability and Management*	3
19	*Foundations and Trends in Accounting*	3
20	*International Journal of Accounting*	3
21	*Journal of Accounting and Public Policy*	3
22	*Journal of Accounting Literature*	3
23	*Journal of Accounting, Auditing and Finance*	3

#	Journal title	ABS Rating
Accounting *(continued)*		
24	*Journal of Business Finance and Accounting*	3
25	*Journal of International Accounting, Auditing and Taxation*	3
26	*Journal of the American Taxation Association*	3
27	*Management Accounting Research*	3
General Management, Ethics, and Social Responsibility		
28	*Academy of Management Journal*	4*
29	*Academy of Management Review*	4*
30	*Administrative Science Quarterly*	4*
31	*Journal of Management*	4*
32	*British Journal of Management*	4
33	*Business Ethics Quarterly*	4
34	*Journal of Management Studies*	4
35	*Academy of Management Perspectives*	3
36	*Business and Society*	3
37	*California Management Review*	3
38	*European Management Review*	3
39	*Harvard Business Review*	3
40	*International Journal of Management Reviews*	3
41	*Journal of Business Ethics*	3
42	*Journal of Business Research*	3
43	*Journal of Management Inquiry*	3
44	*MIT Sloan Management Review*	3
45	*International Journal of Managing Projects in Business*	1

#	Journal title	ABS Rating
Operations and Technology Management		
46	*Journal of Operations Management Production Management*	4*
47	*International Journal of Operations and Production and Operations Management*	4
48	*Computers in Industry*	3
49	*IEEE Transactions on Engineering Management*	3
50	*International Journal of Production Economics*	3
51	*International Journal of Production Research*	3
52	*Journal of Scheduling*	3
53	*Journal of Supply Chain Management*	3
54	*Manufacturing and Service Operations Management*	3
55	*Production Planning and Control*	3
56	*Supply Chain Management: An International Journal*	3
57	*International Journal of Project Management*	2
58	*Project Management Journal*	1
Operations Research and Management Science *(relevant grade 4 and above only)*		
59	*Operations Research*	4*
60	*European Journal of Operational Research*	4
Organization Studies		
61	*Organization Science*	4*
62	*Human Relations*	4
63	*Leadership Quarterly*	4
64	*Organization Studies*	4
65	*Organizational Research Methods*	4
66	*Group and Organization Management*	3
67	*Organization*	3

#	Journal title	ABS Rating
Organization Studies *(continued)*		
68	*Research in Organizational Behavior*	3
69	*Research in the Sociology of Organizations*	3
Public Sector and Healthcare		
70	*Journal of Public Administration: Research and Theory*	4
71	*Public Administration Review*	4
72	*Public Administration: An International Quarterly*	4
73	*Environment and Planning C: Government and Policy and Institutions*	3
74	*Governance: An International Journal of Policy, Administration*	3
75	*Health Services Research*	3
76	*International Review of Administrative Sciences*	3
77	*Journal of European Public Policy*	3
78	*Journal of Policy Analysis and Management*	3
79	*Milbank Quarterly*	3
80	*Policy and Politics*	3
81	*Public Management Review*	3
82	*Regulation and Governance*	3
Regional Studies, Planning, and Environment		
83	*Environment and Planning A*	4
84	*Environment and Planning D: Society and Space*	4
85	*Regional Studies*	3
86	*Journal of Rural Studies*	4

#	Journal title	ABS Rating
Sector studies *(relevant papers only)*		
87	*Transportation Research Part B: Methodological*	4
88	*Transportation Research Part A: Policy and Practice*	3
89	*Transportation Research Part D: Transport and Environment*	3
90	*Transportation Research Part E: Logistics and Transportation Review*	3
Strategy		
91	*Strategic Management Journal*	4*
92	*Global Strategy Journal*	3
93	*Long Range Planning*	3
94	*Strategic Organization*	3
Innovation		
95	*Journal of Product Innovation Management*	4
96	*Research Policy*	4
97	*R&D Management Journal*	3
98	*Technovation*	3
Journals where the concept program and our team have published papers		
99	*European Planning Studies*	2
100	*Facilities*	1
101	*Impact Assessment*	N/a
102	*Impact Assessment and Project Appraisal*	N/a
103	*International Journal of Architecture, Engineering and Construction*	N/a
104	*International Journal of Business Performance Management*	1
105	*International journal of information systems and project management*	N/a
106	*International Journal of Project Organization and Management*	N/a
107	*International Journal of Risk and Contingency Management*	N/a
108	*International Journal of Sustainable Engineering*	N/a

#	Journal title	ABS Rating
Journals where the concept program and our team have published papers *(continued)*		
109	*Journal of Construction Engineering and Management*	2
110	*Journal of Facilities Management*	N/a
111	*Planning Theory*	N/a
112	*Procedia–Social and Behavioral Sciences*	N/a
113	*Procedia Engineering*	N/a
114	*Public Organization Review*	N/a
115	*Public Works Management and Policy*	N/a
116	*Scandinavian Journal of Management*	2
117	*Urban, Planning and Transport Research*	N/a
118	*Engineering Project Organization Journal (EPOJ)*	N/a

Appendix B—EBSCOhost Literature Search Result

#	Keyword used for the literature search		Paired terms				Search result (Number of documents)		
			Paired term 1		Paired term 2				
	Keyword	Field search	Term 1	Field search	Term 2	Field search	Initial search	After being refined with the set of journals	No. of documents used for the study
1. EBSCOhost search result for the primary set of keywords									
I	"Front end"	Abstract	"Project" OR "Portfolio"	Subject terms	—	—	294	The number of articles was manageable so there was no need to refine the result with the set of journals.	44
II	"Project concept"	Abstract					139	The number of articles was manageable so there was no need to refine the result with the set of journals.	4
III	"Conceptual appraisal" OR "Conceptual phase"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms			268	The number of articles was manageable so there was no need to refine the result with the set of journals.	19
IV	"Project owner" OR "Project sponsor" OR "Senior Responsible owner SRO"	Abstract	"role"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms	94	The number of articles was manageable so there was no need to refine the result with the set of journals.	8

V	"Project success criteria" OR "Project success definition"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			67	The number of articles was manageable so there was no need to refine the result with the set of journals.	17
VI	"Project lifecycle" or "Project life cycle"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			471	The number of articles was manageable so there was no need to refine the result with the set of journals.	30
VII	"Optimism bias"	All text	"Project" OR "Program" OR "Program" OR "Portfolio"	Subject terms			124	The number of articles was manageable so there was no need to refine the result with the set of journals.	23
VIII	"Project evaluation" OR "Project appraisal"	Abstract	"Project" OR "Program" OR "Program" OR "Portfolio"	Subject terms			899	67	16
IX	"Quality at entry"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms			250	The number of articles was manageable so there was no need to refine the result with the set of journals.	2
X	"Ex-ante Evaluation" OR "Ex-ante appraisal"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms			68	The number of articles was manageable so there was no need to refine the result with the set of journals.	7

#	Keyword used for the literature search		Paired terms				Search result (Number of documents)		
			Paired term 1		Paired term 2				
	Keyword	Field search	Term 1	Field search	Term 2	Field search	Initial search	After being refined with the set of journals	No. of documents used for the study
1. EBSCOhost search result for the primary set of keywords *(continued)*									
XI	"Project Finance"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			1801	6	4
XII	"Pre-study"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms			67	The number of articles was manageable so there was no need to refine the result with the set of journals.	1
XIII	"Pre-project"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms			179	The search result was manageable so there was no need to refine the result with the set of targeted journals.	15
XIV	"Definition phase" or "Entry phase"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms			240	The search result was manageable so there was no need to refine the result with the set of targeted journals.	3
XV	"Scenario analysis" OR "Scenario planning"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			112	The search result was manageable so there was no need to refine the result with the set of targeted journals.	6

2. EBSCOhost search result for the secondary set of keywords									
A	"Business Case"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			361	22	5
B	"Proposal"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			2,828	8	5
C	"Investment case"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			102	4	2
D	"Strategy"	Abstract	"Decision logic" OR "Rationale" OR "Logical framework" OR "Causality"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms	288	13	5
E	"Project governance"	Abstract	"Systems" OR "Schemes"	All text			53	The search result was manageable so there was no need to refine the result with the set of targeted journals.	4
F	"Estimation" OR "Stochastic estimation"	Abstract	"Strategic" OR "Tactical"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms	102	17	2
G	"Effectiveness"	Abstract	"Cost and benefits"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms	16	The search result was manageable so there was no need to refine the result with the set of targeted journals.	-

#	Keyword used for the literature search		Paired terms				Search result (Number of documents)		
			Paired term 1		Paired term 2				
	Keyword	Field search	Term 1	Field search	Term 2	Field search	Initial search	After being refined with the set of journals	No. of documents used for the study
2. EBSCOhost search result for the secondary set of keywords *(continued)*									
H	"Contract"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			3,274	155	18
I*	"Feasibility" OR "Viability"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			3,632	42	3
J	"Time perspective"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			10	The search result was manageable so there was no need to refine the result with the set of targeted journals.	—
K	"Uncertainty" OR "Risk"	Subject terms	"Project" OR "Program" OR "Portfolio"	Subject terms			7,035	320	35
L	"Decision bias"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			14	The search result was manageable so there was no need to refine the result with the set of targeted journals.	1
M	"Real options"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			75	13	4

N	"Reference class forecasting"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			10	The search result was manageable so there was no need to refine the result with the set of targeted journals.	1
O	"Strategic alignment"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			48	13	6
P	"Design to cost"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			13	The search result was manageable so there was no need to refine the result with the set of targeted journals.	1
Q	"Ideation"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			68	The search result was manageable so there was no need to refine the result with the set of targeted journals.	2
R	"Sustainability"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			1,779	100	11
S	"Cost"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			14,694	654	24
T	"Relevance"	Abstract	"Rationale"	All text			53	The search result was manageable so there was no need to refine the result with the set of targeted journals.	2

#	Keyword used for the literature search		Paired terms				Search result (Number of documents)		
			Paired term 1		Paired term 2				
	Keyword	Field search	Term 1	Field search	Term 2	Field search	Initial search	After being refined with the set of journals	No. of documents used for the study
2. EBSCOhost search result for the secondary set of keywords *(continued)*									
U	"Objectives"	Abstract	"Parallel" OR "Linked" OR "Multiple" OR "Non-aligned"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms	1,222	26	2
V*	"Needs" OR "Preferences" OR "Incentives" OR "Policy"	Abstract	"Analysis" OR "Stakeholders" OR "Perverse" OR "Objective"	All text	"Project" OR "Program" OR "Portfolio"	Subject terms	2,204	256	22
W	"Megaprojects"	Abstract	"Project" OR "Program" OR "Portfolio"	Subject terms			210	The search result was manageable so there was no need to refine the result with the set of targeted journals.	13
						Total	**43,164**	**4,520**	**367**

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