POLITECNICO DI TORINO

Master of Science in Engineering and Management

Master's Degree Thesis

A Framework for Public Infrastructure Construction Project Management

Synthesizing Theoretical Knowledge and Lessons Learned

Supervisors

Dr. Vijay Kanabar

Dr. Alberto De Marco

Candidate

Fabio Mazzocco

S277991

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Abstract

Despite public infrastructure projects historically delivered poor project performance, demand for them is steadily increasing. In the last decades, infrastructure projects got the attention of scholars that generated knowledge with articles and books using exploratory research and analyzing case studies. Today, however, there is still no standard or framework to guide infrastructure project managers. Standard project management frameworks can provide a starting point. Nevertheless, they are unsuitable for more extensive, complex projects involving public interest and money, carrying an unmatched level of risks, changing the environment, attracting political figures, and creating tremendous benefits and value for citizens. This thesis attempts to synthesize knowledge produced in the past decades to craft an initial framework for public construction infrastructure projects that spans from the initial portfolio creation to the recommendations for managing individual megaprojects. The results include a framework that presents concepts drawn from an agile approach. This is by no means a one-size-fits-all framework, but it can help decision-makers and practitioners structure their thinking. One goal is to encourage scholars and professional organizations to consider elaborating a framework for megaproject management.

Keywords: Megaproject Management, Portfolio Management, Project Management, Framework, Infrastructure, Public-Private Partnerships, Agile

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1. Introduction

The introduction to the thesis presents the definition of megaprojects and public construction infrastructure projects, why countries build and desire to increase their infrastructures, and challenges and problems for both infrastructure projects and infrastructure project management. Then, it presents the rationale behind the framework and the research methodology.

1.1 What are Public Construction Infrastructure Projects?

Public construction infrastructure projects indicate the creation of physical infrastructure that is chartered by the public sector, usually governments. The definition includes transport infrastructure – roads, fixed links, and rails – and other major projects that aim to increase the social value for the community. While public infrastructure projects can include information communication technology (ICT) projects, they are not included in the scope of this dissertation. Public construction infrastructure projects will hereby be referred to as infrastructure projects (INFPROs).

Given their characteristics, INFPROs fall under the umbrella definition of "megaprojects". Scholars have long tried to agree on the definition and characteristics of megaprojects. Current research describes megaprojects as projects with: a decades-long life cycle; at least $100 million projects; extensive use of resources; large size; impact on politics, society, and environment; high degree of uncertainty; complexity; and others (Oliomogbe & Smith, 2013). Frick (2008) defines megaprojects using the following six "C" s: colossal size and scope; captivating because of their size, engineering achievements, or aesthetic design; costly – and often under costed; controversial; complex; have control issues (Sturup, 2009). A looser definition considers megaprojects projects that employ many resources, have a human, social, and environmental impact, and are highly complex (Kardes et al., 2013).

It is essential to recognize that megaprojects – and, therefore, INFPROs – are not just magnified projects but also change society's structure. Thus, they are recognized as "trait makers" (Flyvbjerg, 2014).

1.2 The Need for Public Infrastructures

Between 2010 and 2021, around 3,000 INFPROs have been completed across the United Kingdom (UK). The local government allocated £483 billion in infrastructure (Association for Project Management, 2021). The McKinsey Global Institute (2013) estimated that the global infrastructure expenditure between 2013 and 2020 would be $3.4 trillion per year. Moreover, infrastructure building plans continued even after the coronavirus pandemic. For example, the UK planned an additional £37 billion for around 260 projects in the reopening year for infrastructure construction, repair, maintenance, and consulting service (UK's Infrastructure and Projects Authority, 2020). Still, agencies and scholars highlight a deficit of infrastructures despite the significant investments being made at this time (South et al., 2018).

Walter (2016) argues that the main determinant of infrastructure development is its impact on economic performance and growth. Zeng et al. (2015) – who performed a literature review on the topic – adds that INFPROs can positively or negatively impact economic development and promote the economy with scale effects because of production function theory. Notable factors that increase the demand for megaprojects include population growth, urbanization, technological development, enrichment, and increased desire for quality of life (Kardes et al., 2013). The United States (US) provides an example of roads demand, which is 43% higher than capacity. The figure is affected by the statistics that 15% of the roads are in unacceptable conditions, highlighting the need to perform maintenance works on existing infrastructures. Currently, the US loses $100 billion a year due to road congestions (Dobbs et al., 2013). Within this context, INFPROs proved capable of creating value. For instance, transport INFPROs are an example. They provide value for decades by easing transportation and supporting business needs as they connect regions and states (Vuorinen & Martinsuo, 2019). Infrastructures are and will be in demand because of the growing differences between areas in terms of "location of resources and demand, increasing mobility of resources and rapid communications associated with globalization, and increasing populations and faster growing expectations" (Sturup, 2009).

If adequately managed, megaprojects influence the domestic output by creating and sustaining employment and lowering production costs improving productivity and competitiveness. Moreover, they increase the domestic input of imports, enhance the quality of services, and enhance the environmental dimension of sustainability (Flyvbjerg, 2014, 2017).

Most importantly, charting INFPROs is a savvy political choice as there is a strong correlation between infrastructures and productivity. Some cases even demonstrated a causal relationship, but the analysis is complicated because many factors can influence productivity in a region or country (Fernald, 1999; Khanna & Sharma, 2021). For instance, the nonpartisan Congressional Budget Office of the US showed that every dollar spent on infrastructures resulted in $2.2 of economic benefits, and the US Council of Economic Adviser calculated that $1 billion investment in infrastructures supports 13,000 jobs for a year (Katseff et al., 2020). In the UK, the Public Administration and Constitutional Affairs Committee found that every pound spent on infrastructures generates £2.92 for the economy (Beach, 2021). At the same time, closing infrastructures would have a cost both in terms of GDP and the cancellation of jobs (Katseff et al., 2020).

While there are many less commendable reasons for INFPROs (see next section), policymakers and administrations often include INFPROs within the priorities of their political program because of the infrastructure benefits. Nonetheless, INFPROs also have an extended record of failures in providing benefits and often caused disbenefits. For instance, high-quality infrastructures in China have been poorly managed and culminated in financial and economic issues (Ansar et al., 2016). Crescenzi and Rodríguez-Pose (2012) studied a case of an infrastructure development program and found that it did not result in a significant economic performance enhancement in the European Union (EU). Instead, investments in social resources and innovation capabilities were more beneficial. The authors argue that there might be a minimum threshold of INFPROs to heavily impact economic development, and the tendency to select politically advantageous projects can negatively influence the results.

1.3 The Desire for Public Infrastructure Projects

The previous section highlighted the benefits of infrastructure development. However, it is not just a need as many INFPROs are made because of personal desires. In fact, megaprojects grow bigger over time (Flyvbjerg et al., 2004). Flyvbjerg (2017) estimated an annual increase – in value – between 1.5% and 2.5%. The ability to create larger projects and experience in undertaking them suggests that there will be even larger and more complex projects (Flyvbjerg et al., 2004; Sturup, 2009). However, megaprojects are usually fragile because random events can

easily break them. While economies of scale and scope help, the exposure to risks is high. In INFPROs, the paradigm that bigger is always better does not hold (Flyvbjerg, 2017).

Megaprojects are often political decisions (Giezen, 2012). Scholars searched why politicians promote so many INFPROs if they recognize that they often break and create social disbenefits. The findings highlight that they do not just want to exploit the benefits at a national level, but personal reasons and other similar justifications exist. First, INFPROs become tools as political players seek compelling stories for their voters (Rothengatter, 2008). Additionally, being the politician who made an INFPRO possible attracts media attention and becomes history. This is one of the "four sublimes" found by Flyvbjerg (2014). Sublimes are political, economic, technological, and aesthetical. The economic sublime attracts businesspeople and trade unions because of the possible involvement of the private sector and employment opportunities. The technological sublime triggers the interest of engineers, scientists, and the like because of the possibility of deploying new technologies and creating "a first". The aesthetic sublime gathers the attention of designers and design-conscious people (Flyvbjerg, 2014).

1.4 Challenges for Public Infrastructure Projects

Notwithstanding the benefits, the need and desire for infrastructure development, INFPROs face many challenges because of their nature. While the problems with INFPRO management are presented in the next section, their very essence indicates that a different project management approach is needed, and traditional project management does not suffice.

Firstly, megaprojects are inherently controversial as the significant investment must be repaid (van den Ende & van Marrewijk, 2019; Zeng et al., 2015). They are extreme cases of projects dominated by complexity and internal and external dynamic instability (Kardes et al., 2013; Sato & de Freitas Chagas, 2014). In particular, complexity arises due to the long duration of megaprojects, the possible changes during the project life cycle, and the technological complexity (Kardes et al., 2013). For instance, a sample of 60 megaprojects had a front-end phase – the initial feasibility study and planning – that lasted on average seven years (Miller & Hobbs, 2005). Moreover, each year of delay in construction megaprojects results in 4.64% cost overruns (Flyvbjerg, 2017).

Megaproject challenges include:

- intrinsic riskiness;

- frequently management and designers change;
- several interests from different stakeholders;
- uniqueness bias as opposed to learning from other projects;
- lock-in effect and absence of the "failing fast" philosophy;
- principal-agent problems, rent-seeking behavior, and optimism bias are common due to the high sum of money involved; high-risk delivery with possible "black swans";
- inadequate complexity and unplanned events identification; and
- cost, schedule, benefits, and risks misinformation that lead to cost overruns (Flyvbjerg, 2014).

Another critical factor is the internationality of megaprojects' scope as they frequently involve contractors, sponsors, and funds from different countries (Kardes et al., 2013). INFPROs often use new technologies that can result in technical successes but, at the same time, in financial failures (Flyvbjerg, 2014; Kardes et al., 2013). Moreover, megaprojects have many stakeholders and attract even more due to the potential political and social impact (Fahri et al., 2015).

INFPROs are inextricably entangled with their institutional environment, spanning institutional boundaries and encapsulating diverse and conflicting institutional frameworks (van den Ende & van Marrewijk, 2019). Furthermore, INFPROs have several externalities. Environmental and societal impacts include community displacement, biodiversity and ecosystem damages, flooding, water pollution, erosion, landslide, and deforestation. Noise, air, and other types of pollution can affect society ad create disbenefits. All these factors must be considered (Cvijović et al., 2021).

1.5 Problems with Public Infrastructure Project Management

There are specific problems that project, program, and portfolio managers must face in their jobs when working on megaprojects and INFPROs. This section presents some of them, and potential solutions are explored in the following chapters.

The iron law of megaprojects – including INFPROs – is "over budget, over time, over and over again" (Flyvbjerg, 2017). Despite such a paradigm, megaprojects are in great demand, generating the so-called megaprojects paradox (Flyvbjerg, 2017). Managers and planners do not

know how to deliver a megaproject, so they start and only later find that estimations are too optimistic or manipulated, resulting in the project "breaking", which is then fixed by pausing and reorganizing. This is the break-fix model, which causes an inefficient allocation of resources. The only way to stop the break-fix model is to avoid it to break, so get the front-end management well in the first place (Flyvbjerg, 2014; Gellert & Lynch, 2003). If a system or process systematically delivers poor outcomes, it indicates fragility (Flyvbjerg, 2017).

One of the reasons why megaprojects are challenging is that they experience uncommon levels of risks, uncertainty, and complexity (Kardes et al., 2013; Miller & Hobbs, 2005; Mok et al., 2015). Despite the technical difficulties of such large projects, stakeholders and the conflicts they originate are the primary threat and sources of uncertainty (van den Ende & van Marrewijk, 2019). In fact, INFPROs have a much higher number of stakeholders than a standard project. Additional sources of uncertainty are found in the project dynamics, growing capacity, and the complex governance structure (Mok et al., 2015).

Megaprojects also encompass a high number of different, ambiguous, and interconnected activities that increase project complexity (Kardes et al., 2013). Indeed, hidden processes – especially at scale like for megaprojects – increase fragility, creating a need for redundancy or cushion effect (Flyvbjerg, 2017). The number of activities results in long project duration. That is a cause of problems as the duration of the implementation phase and cost overruns are correlated. Such a phenomenon has already been described, but it should not become an excuse for fast-tracking and rushing to start the project as the front-end phase must be thorough (Flyvbjerg, 2014).

Project management issues also originate because some project promoters believe it is justifiable to "cook" costs because the megaproject will benefit society. This reasoning is faulty as sustainable benefits consider the economic dimension. However, project promoters decide to "cook" costs as they profit from biased cost-benefit analyses (CBAs). In fact, CBAs generate two "positive" effects: the project is started despite not being financially viable and prevents other projects with higher cost-benefit ratios from being started. Thus, project promoters have incentives to do so. However, this is illegal and creates moral issues. Projects with enough benefits and contained costs exist, and misrepresentation is not needed to start megaprojects. It should be noted that INFPROs are so large that they can take down even the most powerful leaders, such as CEOs and presidents. Today, strategic misrepresentation starts to be attacked by

scholars and project professionals. Entire countries can suffer from a wrong megaproject. Fortunately, there is light at the end of the tunnel. Private funds encourage advisors and audits to protect private funding, undermining the excessive trust that is often a problem. The democratic governance is getting stronger too. Scholarly works are finally impacting practice and policies (Flyvbjerg, 2014).

1.6 The Need for a Framework

As aforementioned, megaprojects are not only massive projects, but they are factors that influence the GDP of a country, the productivity of regions, equality, access to jobs, employment, immigration, and much more. Standard project management knowledge is not enough to address the challenges of INFPROs. Standard project management frameworks can provide the basis for INFPROs, but they must be heavily adapted. To that end, organizing scholarly literature that often recalls practitioners' knowledge can provide a base for a new INFPRO-specific framework.

This thesis attempts to create an initial framework to be adapted for different projects instead of an INFPRO management methodology because a cookie-cutter approach to megaprojects is no longer suitable (Sturup, 2009). Instead, a framework can help structure government and project managers' thinking and decision-making processes. It allows considering most areas that require management and possible approaches to each of them. In a way, it is an attempt to emulate other standard project management frameworks or standards such as the PMBOK® guide by PMI, the APM Body of Knowledge, or the Individual Competence Baseline by IPMA.

1.7 The Limits of a Framework

As aforementioned, a framework does not provide a step-by-step guide or the structure of a methodology such as Prince2 by the UK government. A framework requires adaptation depending on the case, including considering additional aspects, repeating some considerations at different times, and the like.

This framework synthesizes and structures most lessons learned and theoretical suggestions recorded and produced by scholars so far. However, as new knowledge will appear – especially during this wave of interest about INFPROs, more frameworks can emerge, and this

one can be revolutionized if needed. To that end, the author hopes to see new frameworks develop or completely change this one.

1.8 Goals of this Framework

Given the limitations, the goal of this framework cannot be to create a new one-size-fits-all structure for INFPROs, but rather to encourage scholars, practitioners, and professional associations to recognize the difference in megaproject management with the standards for project management. In fact, the INFPRO framework is just the starting point to craft more efficient and comprehensive frameworks to improve INFPRO success around the world. That includes reducing costs and improving benefits, eventually increasing national welfare by providing a higher community value.

1.9 Research Methodology

The dissertation uses explorative research, drawing from peer-reviewed articles and books that analyze INFPROs or their category, i.e., megaprojects. Some figures were drawn from country reports or specialized consulting companies.

A complete review of all the articles regarding megaprojects and, in particular, INFPROs was not feasible. However, the research articles included several case studies and credible cited articles, including meta-analyses. Several case studies have been included as scholars stated their importance (Greiman, 2014). To that end, most of the references are peer-reviewed – except for some consulting companies' reports for figures. The author used Boston University's library and Google Scholar, looking for keywords such as "Infrastructure", "megaprojects", "project management", "sustainability", and their combinations.

The research aims to synthesize the findings of the many articles into a single framework. This dissertation does not include implementation methods, as such effort would result in decades of experiments or extensive quantitative data collection. Implementation research will be the next step in the emerging field of megaproject research.

1.10 Next Sections

The following sections introduce the framework "levels". They then dive deeper into the different considerations, presenting why they have been included in the scheme with takeaways from case studies and other scholarly produced knowledge.

The first section introduces the scope of the framework, its rationale, and the needed mindset for using it. It also includes a graphical representation that helps connect the different parts. The second section dives into the strategic level, moving from collecting community needs to creating an INFPROs portfolio. Chapter four presents the tactical level, spanning from general INFPROs environment considerations to the selection of projects, and including considerations about other aspects like procurement method, contract management, governance, ethics, and the like. Operational aspects are addressed in the fifth chapter, limiting the discussion to the high-level elements without a more profound project-level framework. The last chapter presents the conclusions, managerial application, and limitations of the research.

2. Introduction to the Framework

This chapter first introduces the scope of the INFPRO framework, the right way to use the framework, and a graphical way to visualize the framework. The second part gives an overview of the framework's three levels and presents the concept of INFPRO agility embedded in the model.

2.1 Scope of the Framework

The framework presented in this thesis focuses on touching the right aspects of public infrastructure construction project management from the public sector's point of view. The author recognizes that all the infrastructure projects are different, but the main problem areas are shared. The scheme allows governmental decision-makers to frame their thinking in terms of sequence and interconnection of topics that need to be tackled.

Given the presence of the private sector in the procurement method, suggestions can also be used by the contractors or contractor consortium. Nonetheless, this framework wants to be directed at the public sector.

The idea of an INFPRO framework can be seen as an attempt to start a body of knowledge for INFPROs similar to the 7th edition of PMI's PMBOK® Guide. It does not prescribe processes and knowledge areas but rather indicates some "infrastructure projects performance domains" and adds a layered structure.

A step-by-step guide for public decision-makers and private players or a one-size-fits-all megaprojects framework is out-of-scope. Moreover, a careful analysis can specify knowledge areas and process groups with input, processes, and outputs. However, given the heterogeneity of INFPROs, creating a framework is already a stretch per se. Therefore, additional research must not lean toward a methodology but rather an approach or framework.

As aforementioned, the framework mostly tackles public infrastructure construction projects and has the potential to be applied to different types of public megaprojects such as IT infrastructures. However, it is not within the scope of this thesis to include them.

2.2 Architecture of the Framework

At a high level, the framework is divided into three main sections: the strategic, tactical, and operational levels. Each of them must be thought of as dependent on the one above. The idea

is that tactics and operations cannot exist but because of a strategic plan, and operations as resulting from the tactics. While this might sound trivial because it is already established in companies, this is not always the case for INFPROs.

Each level can be iterated until satisfying outputs are produced. They can also be adjusted based on emerging knowledge – including from lower levels - or changes in the environment. In general, if the upper levels change, the lower levels should change accordingly. However, lower levels can identify whether changes to upper levels are required.

Many politicians tend to initiate megaprojects because of the political sublime, leaving INFPROs as stand-alone projects. Instead, the author suggests a portfolio view that aims to identify needs, create a vision and mission, define goals, objectives, and a strategy, and translate it to operations through tactics – including selecting the suitable projects at the right time.

Decision-makers must enlarge the period after which success is measured. Benefits can be realized in the short-run, middle-run, and long-run, and they should be balanced among these three measuring periods. While INFPROs portfolios can quickly increase employment, they might harm the job market in the area in the long run. Conversely, they could cost more in the short term but be future-ready. Like the one presented in this thesis, any framework for megaprojects should balance the interests, recognizing that political, economic, technological, and aesthetic sublimes are real and must be considered.

Therefore, while the framework provides suggestions about the most practical problems with INFPROs management, including stakeholder management, contract management, sustainability assessment, risk management, and the like, it also provides the general direction to have long-term sustainable value and achieve success.

On top of the main success areas, the framework provides additional suggestions to improve the megaproject performance, including creating a national Portfolio Management Office (PMO) that acts as a center of excellence in activities like knowledge sharing and project management support.

2.3 Visualizing the Framework

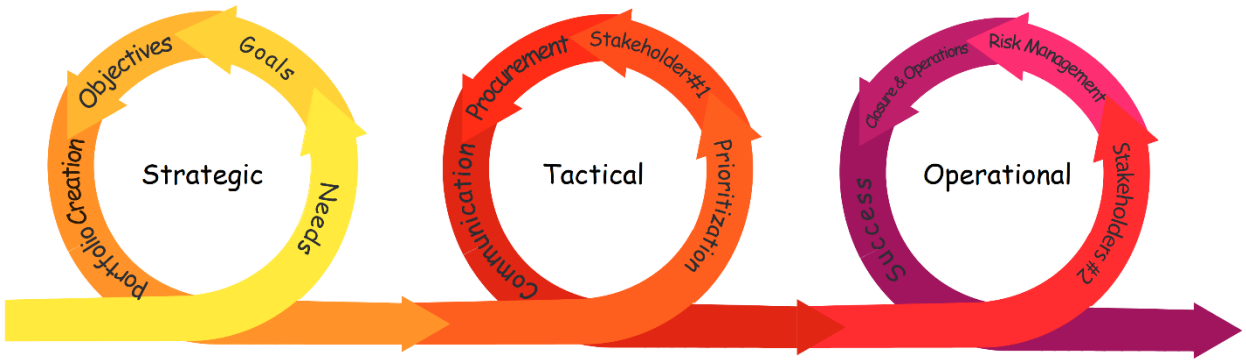

Figure 1 - The INFPRO Framework

The author considers a graphical representation of the framework crucial to its implementation. While different parts can be explained, a graphical representation allows one to survey the framework quickly and connect the dots. The visual representation of the framework also presents the idea of iteration and connection to the upper levels. The three levels are voluntarily inspired by the visual representation of the Scrum methodology. While this framework does not suggest an application of Scrum to INFPROs, it recalls some agile concepts. For instance, stakeholders are heavily involved, and modularity is encouraged.

Overall, each cycle can be repeated until the level is satisfactorily developed, and the next level can rely on the concepts developed in the previous level. The following paragraphs present the overall structure of the strategic, tactical, and operational levels.

2.4 Strategic Level

Before starting with the steps, the strategic layer introduced the need to create long-term results. To that end, the author suggests having sustainable goals that last over time. A long-time perspective also has additional perks, but it needs an entirely new approach to projects, i.e., sustainable project management. When choosing the initiatives, single projects will rarely provide long-term benefits if they are not complemented with other initiatives. For instance, new roads must come with a power supply infrastructure for electric cars.

The INFPRO framework starts with the identification of the country or regional needs over the long run. To that end, the author suggests relying on the governance structure to gather new needs as they arise and adjust the overall goals of the portfolio. They are polished and

formalized into a vision and mission. Then, goals and objectives are identified, along with the strategy to achieve them. Subsequently, there is the first stakeholder involvement to gather ideas on possible projects, and the portfolio is created. Additionally, a Benefits Realization Management plan is crafted.

The strategic level ends with two additional considerations. First, the need to consider the cultural and geopolitical factors as different countries and cultures will need a different project management approach. Second, creating a nationwide Portfolio Management Office (PMO) can contribute to long-term success.

2.5 Tactical Level

Once the portfolio has different projects to choose from, it is important to prioritize them. However, before doing that, the general INFPROs environment is presented. Additionally, approaches to political support, contested information, the threat of the lock-in effect, approaches to decision-making and leadership, and the need to implement system thinking are presented. The first part of the tactical level chapter ends with a justification for a modular and fast approach to infrastructure development, the general megaproject life cycle, and the need for knowledge management in the portfolio.

The first areas of interest in the tactical level are assessing projects' expected benefits, costs, and ideal timing. This section includes methodologies to assess the value creation, as well as criteria. It also presents problems and solutions of estimations and the need to mind uncertainty resulting from new technologies and disruption that megaprojects can bring.

Once the projects have been selected, the first step is to involve stakeholders, including the public. That is important to co-design the infrastructure, identify concerns, and communicate with transparency. The framework also addresses possible protests and their effects.

Before starting the selected projects, decision-makers select the proper procurement method for the project. Once the general idea of the INFPRO is shaped with the stakeholders, it is vital to choose the right procurement method and the right contractors or contractor consortium. To that end, different procurement methods and the need for consistency are presented. Factors include efficiency, risk sharing, financial considerations, agency cost, recouping money, and delivering value for money. When selecting contractors or consortia, it is

important to design the bidding process correctly, encourage bidders to present their tender offer, and choose appropriate criteria.

A brief section introduces the importance of transparency and communication management throughout the whole INFPRO life cycle, including with the public.

Furthermore, a section is dedicated to contracts and contractors because they are among the most important stakeholders. Therefore, it is crucial to devise a well-crafted contract and choose the proper contract type starting from a contracting strategy. Then, the government must consider the content and how to relate with contractors through contractor relationship management.

Finally, the whole level is put together through extensive governance and the use of ethical principles. At this point, obtaining an early win boosts the chances of success of the portfolio.

2.6 Operational Level

The operational level presents recommendations about general approaches for the management of individual infrastructure projects.

First, it is crucial to mind sustainability and additional value opportunities that might arise due to the openness of possibilities and the level of uncertainty. The author suggests a "keep the eyes open" approach as opportunities emerge throughout the project and can increase the value of the infrastructure, from the front-end to the INFPRO operations. Anticipating possible problems will also result in fewer disbenefits during the project implementation.

Managing stakeholders at a project level is essential as they influence the project once it is announced and, most importantly, during project execution. One of the recommendations is to identify the Most Valuable Stakeholder (MVS) in each INFPRO phase, as it leads other stakeholders in responding. At the same time, all the stakeholders, particularly the general public, must be engaged and informed about project news and site.

A section addresses risk management topics. Because of the intrinsic riskiness of megaprojects, it is essential to implement risk management by considering categories and strategies, assessing the overall risk, and sharing risks with the contractors whenever possible. Eventually, some common risks and general recommendations are presented.

Finally, there are sections about using technology to reduce risks and costs while enhancing benefits, considerations about the project closure, and the following operations phase. The framework concludes with the concept and measurement criteria of success.

2.7 Infrastructure and Agility

As aforementioned, the INFPRO framework draws concepts from the agile approach. First, it considers the importance of value. It is not just defined but assessed through continuous interaction with stakeholders and the general public. The latter can be considered the client as the government work for creating community value.

Second, there is modularity in the projects and possible scalability through iterations. It allows quick learning and the possibility to change direction and adapt to change. Considering that one of the distinctive characteristics of INFPROs is uncertainty, this concept fits nicely into the framework and addresses the leading causes for failure.

A crucial aspect is a focus on value and success in terms of stakeholder value. Decision-makers not only aim to satisfy the iron triangle of budget, schedule, and scope but also consider the community's perceived success.

Additional characteristics that also appear in the Agile approach include the importance of knowledge sharing, collaboration principles in the procurement method, the importance of an early win, and value opportunity exploitation.

Agile methodologies for INFPROs have not been studied due to a lack of projects that implement them. However, Jalali Sohi (2018) studied six INFPROs that used either Scrum or waterfall and found that the former performed better in terms of time and cost. The daily standups and the other Scrum events helped reduce reworks and enhanced risk identification and assessment. However, there are still several challenges in the implementation of an agile methodology. For instance, event attendance for construction workers is challenging because they work on multiple projects. Moreover, demoing appears difficult when the client is in public administration. Therefore, Agile for INFPROs requires scholars' attention as it presents promising results but also many challenges.

On the other hand, Lean principles are extensively applied to megaprojects. AgiLean is a joint form of Lean and Agile that can be beneficial for project success. It uses Lean to reduce waste and Agile to deal with changes and uncertainty (Demir et al., 2012).

In general, the use of purely agile methodologies cannot be yet recommended. However, a hybrid method can help, as Agile brings the required flexibility to tackle INFPROs' high level of complexity (Eriksson et al., 2017).

3. Strategic Level

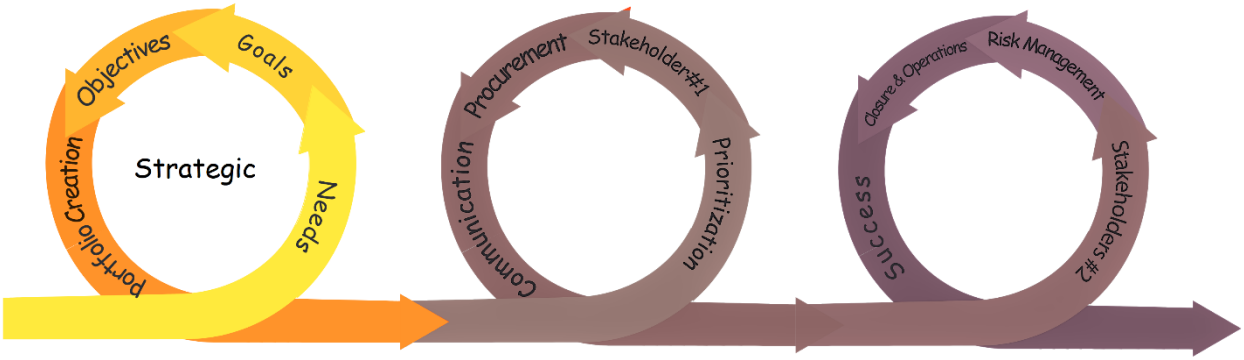

Figure 2 - INFPRO Framework, Highlight on the Strategic Level

Stand-alone megaprojects – including INFPROs – can be seen as "temporary organizations" as these large-scale projects are established as autonomous organizations during the project's existence (Sato & de Freitas Chagas, 2014). More so, if there is a need for several INFPROs to serve different parts of the country, connect regions, or solve nationwide economic and quality of life problems, the government can create an organization. The organization does not need to be formal, but it requires a vision, mission, goals, objectives, and a strategy.

This chapter introduces the importance of a long-term perspective and the need for a portfolio of projects and operations. It presents the idea of collecting nationwide high-level needs, implementing a method to update such needs, polish them, and ultimately formalize them into goals and objectives. Once there are measurable objectives, a strategy is needed. At this point, project ideas can be collected.

The chapter also touches on the importance of adapting the approach and projects to the cultural and geopolitical aspects and the benefits of a national Portfolio Management Office.

3.1 A Long-Term Perspective

INFPROs attempt to solve issues and create long-term improvements for the current project. An individual infrastructure development project lasts for years, and the infrastructure itself lasts for decades. Collections of INFPROs and the following operation phase, i.e., the INFPRO portfolio, demand a long-term perspective. Flammer and Bansal (2017) found that, in companies, a long-term perspective enhances the creation of value. A similar approach to INFPROs can be conducive to the success of the initiative. To that end, sustainable goals and

sustainable project management are recommended as they address the vital issue of environmental sustainability. Moreover, a sustainability perspective provides perks. It is no coincidence that countries with a long-term-oriented culture perform well in all aspects of sustainability (Meng et al., 2018).

3.1.1 Sustainable Goals

Megaprojects affect society and the environment years after completion (Eskerod & Ang, 2017). Having a life cycle standpoint in INFPROs allows focusing on the long-term goals, which can deliver better results than focusing on the acceptance of the project during the close-out phase (Fahri et al., 2015). To that end, it is crucial to have a long-term perspective when considering INFPROs and their portfolio. Sustainability plays a vital role as the project goals should be sustainable. On the other hand, sustainability considerations must also be included during infrastructure operations while choosing materials and disposing of them (Oehlmann, 2010). In recent years, governments have been shifting their focus, placing less value on the effects on the sole gross domestic product (GDP) and considering sustainability goals instead (Zeng et al., 2015).

Nowadays, sustainability is a goal in most projects, and sustainable project management is particularly relevant for INFPROs. Both sustainability and sustainable project management play a lead role in changing communities and involving several stakeholders (Kivilä et al., 2017; Toljaga-Nikolic et al., 2020). The United Nation's World Commission on Environment and Development defined sustainable development as "development that meets the needs of the present without compromising the ability of future generations to meet their own needs" (Kivilä et al., 2017; WCED, 1987). INFPROs should satisfy three sustainability dimensions: social, environmental, and economic. The three pillars of sustainability are also referred to as the triple bottom line (3BL or 3Ps) as they are named People, Planed, and Profit (Elkington, 1997; Oehlmann, 2010). The People dimension involves the communities and workers with issues like reducing poverty, good working conditions, community development, integration of immigrants, democracy, and the like. The Planet dimension revolves around the balance between the environmental weight and the capacity of the Earth to bear such weight. The Profit pillar refers to economic viability (Oehlmann, 2010).

Any project and the overall project portfolio should include sustainability as their goals. Sustainability can be both considered a project success factor and a project success criterion

(Dubois & Silvius, 2020). The importance of such a topic in INFPROs is that such projects and portfolios last and operate for decades (Kardes et al., 2013). Thus, if the three dimensions are not satisfied, the value decreases, and the cost-benefit ratio might not support projects anymore. For instance, an infrastructure might have to be shut down because the operator finds it to no longer be economically viable despite creating great benefits in social and environmental terms. At the same time, if it is economically viable, infrastructures might result in negative externalities that demand for a new environmentally friendly infrastructure. Finally, even if environmentally and economically viable, infrastructures must consider the social dimension as many great projects required the movement of towns or even natives that opposed the project, hindering the construction and eventually cancelling the project with all its sunk cost.

It should be noted that sustainability will enlarge the project scope. Therefore, it should be anchored to the business case (Koke & Moehler, 2019). Governments must consider it as part of the long-term perspective and allocate additional funds to improve the chances of success over the long run.

In the past, the only sustainability policies in the EU were related to minimizing the environmental impact and similar objectives for equity, accessibility, and long-term cash flow (Bristow & Nellthorp, 2000). Today, the EU and its national governments incorporate the triple bottom line (Hueskes et al., 2017). However, the social dimension is still poorly represented among the different indicators (Zamojska & Próchniak, 2017). This is the case because of the difficulty in assessing the social dimension, which makes new approaches necessary. Megaprojects must not only be efficient and compliant with laws but be equitable and fair to the community while gathering its acceptance (van den Ende & van Marrewijk, 2019). That is the case because INFPROs have a social responsibility (Zeng et al., 2015). Social benefits include better living conditions, more jobs, social services, and social cohesion (Zamojska & Próchniak, 2017).

While developing an INFPROs portfolio, the balance of infrastructures between territories and urban-rural areas should be a goal as part of the social dimension. The European Commission (2011) of the European Union (EU) describes the concept of territorial cohesiveness as "a set of principles for harmonious, balanced, efficient, sustainable territorial development. It enables equal opportunities for citizens and enterprises, wherever they are located, to make the most of their territorial potentials. Territorial cohesion reinforces the principle of solidarity to

promote convergence between the economies of better-off territories and those whose development is lagging behind" (Clifton et al., 2016). Santinha (2014) decompose territorial cohesion in three main points: reaching a harmonious development of different areas by increasing equality among them; minding the differences and similarities of different territories for better organizing their development; making different policies and policy-makers interact and cooperate for a territorial approach (Clifton et al., 2016).

Some scholars state that INFPROs should be undertaken even if they create social value but not monetary (Zamojska & Próchniak, 2017). However, this is not aligned with sustainable development.

Infrastructures should bolster the quality of life and increase economic possibilities. Consequently, they must be designed thinking about the future. For instance, the design and construction of roads must consider autonomous vehicles and the growing population (U. K. National Infrastructure Commission, 2018).

Oehlmann (2010) argues that sustainability involves some risks too, as it requires long-term investments, and it is not defined whether it will be paid back. Moreover, sustainability makes planning harder because of variations in the design, contractors, required materials and equipment, coordination, and unexpected circumstances (Dubois & Silvius, 2020). Notably, if INFPROs all begin with sustainability goals in mind, there will be learning and knowledge transfer (see the dedicated section in the Tactical Level chapter) because the PMO owns and is accountable for the task. Moreover, a sustainability approach might be burdensome and require additional resources in the short term, but it increases the chances of providing benefits for a much longer time frame.

3.1.2 Perks of a Long-Term Perspective

Having a long-term perspective in infrastructure project portfolios plays a vital role because it opens the opportunity for the creation of a long-term plan which provides more clarity for both industry and suppliers and ensures funding (U. K. National Infrastructure Commission, 2018).

A long-term perspective will also consider the externalities of projects, balancing short- and long-term value. A long-term perspective will also suggest whether short-term benefits with maintenance can be sufficient as they restore the infrastructure performance while preparing more transformative projects that cannot be performed yet (Katseff et al., 2020). In fact, while

assessing, planning, and designing the project and its product, it is crucial to consider the operations phase and the related value opportunities that can arise during such phases (Eskerod et al., 2018).

Finally, a long-term perspective suggests that maximizing positive outputs will increase the value more than minimizing negative ones. That is possible through an INFPRO portfolio (Zamojska & Próchniak, 2017).

3.1.3 Sustainable Project Management

Sustainable development is concerned with defining social welfare goals and the way to achieve them. Sustainable development results from the sustainable use of the four types of capital – manufactured, natural, human, and social (Ekins, 1992; Ekins et al., 2008). If there are sustainable goals, they should be reflected in project management (Dubois & Silvius, 2020; Oehlmann, 2010; Toljaga-Nikolic et al., 2020). Sustainable Project Management (SPM) is a way to implement sustainability practically. SPM involves life cycle thinking and stakeholder cooperation (Kivilä et al., 2017). It incorporates both project process sustainability – sustainability of the project (SoP) – and project product sustainability – sustainability by the project (SbP) (Dubois & Silvius, 2020; Huemann & Silvius, 2017; Khalifeh et al., 2019). SbP involves sustainability to define or assess the content-related aspects of the projects such as design, project deliverables, materials used, benefits, and quality and success criteria. SoP encompasses project delivery, management, and governance in aspects such as stakeholder management, green procurement and partnerships, development of the business case, monitoring, communication, risk management, sustainability knowledge areas and project management processes, project social responsibility, and team management (Dubois & Silvius, 2020; Khalifeh et al., 2019).

SPM can be defined as "the planning, monitoring and controlling of project delivery and support processes, with consideration of the environmental, economic and social aspects of the life-cycle of the project's resources, processes, deliverables and effects, aimed at realizing benefits for stakeholders, and performed in a transparent, fair and ethical way that includes proactive stakeholder participation" (Dubois & Silvius, 2020; Silvius & Schipper, 2014). Project managers must understand the importance of the new duties and responsibilities, starting from a clear understanding of the meaning of sustainability. However, few project managers receive training about sustainability competencies despite the importance of methodologies and tools

(Moehler et al., 2018). It should be noted that project managers have sustainability responsibilities, but also the PMO, the project sponsor, and the project user must face the complex sustainability problem (Metcalf & Benn, 2013; Silvius et al., 2012).

Silvius et al. (2012) argue that sustainability first needs a mind shift that leads to a paradigm shift and eventually turns into a scope shift. Project managers move from managing according to scope, budget, and schedule to managing the project according to the triple bottom line. Figure 5.1 in Silvius et al. (2012) shows the comparison between the old and new approaches.

There are both internal (innovativeness, competitiveness, flexibility, openness, and ability to win and maintain customers) and external pressures to include sustainability into project management (Oehlmann, 2010; Toljaga-Nikolic et al., 2020). One of the main problems of SPM is balancing the social, economic, and environmental dimensions (Khalifeh et al., 2019).

The six principles of sustainability in project management are: balancing and harmonizing social, environmental, and economic interests; having both short-term and long-term views, thinking both about the project and the product; local and global orientation, thinking about all of the stakeholders; a need for value and ethics in the leadership and among consumers to lead the right behaviors and attitude; transparency and accountability; and consuming income instead of capital (Koke & Moehler, 2019).

One of the main goals of sustainable project managers in INFPROs is to improve what Maltzman (2011) calls "greenality", defined as the degree to which organizations consider the environmental dimension of sustainability throughout the infrastructure life cycle. The term is purposely similar to quality as greenality should recall green quality.

Toljaga-Nikolic et al. (2020) argue that an agile approach is conducive to introducing sustainability dimensions into project management, even at a late stage. This is because it addresses uncertainty and provides flexibility and openness, which are some of the aforementioned internal pressures. Moreover, Agile improves the presence of appropriate human resources (HR) practices and decreases the consistency of internal processes. In contrast, Agile requires additional technical skills but increases the collaboration with stakeholders. Therefore, there is a correlation between agile methodologies and the social dimension of sustainability (Toljaga-Nikolic et al., 2020).

Overall, a well-defined project management methodology is crucial to introduce sustainability dimensions into project management and explore the possibilities for linking those methodologies with sustainable dimensions. The problem is that the private sector usually employs various methodologies – including agile ones. Instead, the public sector uses standard frameworks. For instance, in the United States, the public sector uses the Project Management Institute's methodologies (Toljaga-Nikolic et al., 2020). Such difference should lead to considerations about the employed methodology in the case of private sector involvement, as alignment is preferred. The compatibility of different methodologies should be considered during the selection of the contractor consortium. The public sector has less knowledge about sustainability principles. However, if the public sector takes a leadership role in deploying green solutions, the green supplies in the private sector will improve (Toljaga-Nikolic et al., 2020).

It should be noted that sustainability concepts must be adapted for project management in different phases and functional areas (Toljaga-Nikolic et al., 2020). In general, project managers implement SPM by thinking outside the box to achieve sustainable goals while considering the project's effects (Toljaga-Nikolic et al., 2020). The most important skills for project management sustainability are communication and decision-making. These skills are supported by problem-solving, leadership, and teamwork. The sustainable project management skillset is complemented by resource management and quality management as internally-oriented skills, and scope and stakeholder management as externally-oriented ones (Toljaga-Nikolic et al., 2020)

There is a framework for SPM that also applies to INFPROs, namely, the Sustainable Footprint Methodology. It considers three moments of the project and product life cycle and analyzes them based on the triple bottom line. The methodology assigns criteria for each combination of the 3x3 matrix, with project pre-phase, project execution, and operations on one dimension and people, profit, and planet on the other.

In terms of SPM applicable methodologies, project managers can consider concepts from Green Project Management (GreenPM) and Project Integrating Sustainable Methods (PRiSM). GreenPM enables decision–making while considering the environmental impact. PRiSM is a process-based, structured methodology for sustainable change management. However, both are commercial methodologies and need more testing, mainly in public projects (Moehler et al., 2018).

Given the importance of a life cycle view, Life Cycle Assessment (LCA) is a useful analytical tool to encourage life cycle thinking. Moreover, Strategic Management tools such as the Balanced Scorecard can present a basis to incorporate sustainability (Moehler et al., 2018).

This thesis advocates for sustainable project management, life cycle thinking, and stakeholder cooperation, as most scholars' findings support such choices in INFPROs. SPM supports project success and improves stakeholders' satisfaction (Dubois & Silvius, 2020; Khalifeh et al., 2019). Dubois and Silvius (2020) emphasize that while benefits are unequivocal, there is some degree of uncertainty about costs because of the use of more sustainable materials. However, project success is no longer intended as the iron triangle, but SPM supports project success (Khalifeh et al., 2019).

3.2 Complementary Initiatives

While keeping a long-term vision, it is clear that different initiatives must support each other. For instance, more efficient roads can include investments in an internet of things (IoT) infrastructure in the national highways. Other examples include the creation of energy infrastructures along highways for electric cars. Even two different types of infrastructures can increase the quality of life more than the sum of the individual projects. An example is the creation of a highway that dramatically increases its impact if the portfolio includes a bridge that cuts the time or connects more cities. There must be a system vision – rather than stand-alone projects – to increase the value of existing or new INFPROs.

A long-term perspective recognizes that it is essential to exploit opportunities when building new infrastructure or performing maintenance works on an existing one. Renewing the power grid along a highway can be one of those opportunity exploits. However, this is not the only example. In fact, a road might become much more efficient if a bridge is also built to save time.

Taking all the arguments into account, it is important to recognize the complementarity of different proposed projects or add complementary initiatives to increase the value. Therefore, in the portfolio, there will be a collection of projects that, if performed together, are conducive to value enhancement.

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3.3 Capturing the Needs

Once the general mindset of the framework has been defined, it is finally time to dive into the strategic level. The first step in megaprojects is the "search" phase when the needs and solutions are sorted out. This phase can last for decades (Miller & Hobbs, 2005).

3.3.1 Recognizing Public Needs

It is often the case that INFPROs are searching for a reason to be undertaken. They are not the solution to a rational problem. There exists, therefore, a lack of attention to strategic success (Sturup, 2009). Instead, INFPROs should derive from the community and national needs. Consequently, there must be a method to collect and formally state the public need. With public needs, the author does not just indicate local and regional needs that might be solved with one or a few projects, but rather nationwide economic, social, and environmental needs. Needs can take the form of an increase in the quality of life in the country's rural areas or a productivity increase, among others. Needs can then be aggregated to find overarching needs.

Eskerod and Ang (2017) argue that stakeholders should be allowed to add any success criteria in projects they want. The reason is that INFPROs are made to create stakeholder value, and stakeholders should judge whether it has been created. As aforementioned, that does not mean stand-alone needs but refers to the quality of life, urbanization, and access to resources. To that end, citizens, companies, governmental agencies, and other stakeholders should make their voices heard, and the government must interpret such requests and formulate needs.

The framework suggests such an obvious step because megaprojects must start with a problem rather than the megaproject itself – which should represent the solution to such a problem. Unfortunately, that is not always the case. Needs are essential because the selection of the projects must be assessed against the problem analysis (Priemus, 2010).

3.3.2 Future-Proofing Infrastructures

Infrastructure success depends on its ability to respond to future challenges (U. K. National Infrastructure Commission, 2018). Therefore, projects should address the challenges of the present but anticipate future challenges, too.

INFPROs last for decades, and it takes a long time to develop new infrastructures. Therefore, they must provide benefits for many years and not be frequently adapted to chase foreseeable new needs. While decision-makers do not have a crystal ball, they can analyze trends

and emerging needs before selecting and designing an INFPRO. That way, they can address future needs in advance.

3.4 Refining the Needs

Once needs are collected, they are still in rough form. Therefore, they need to be polished. Indeed, with time and experience gathering need, decision-makers will naturally refine the findings, but it might not be enough. To that end, translating needs into a vision and mission statement encourages thinking, synthesis of ideas, and refinement.

Once needs are collected, they must be processed among decision-makers and formalized into a few sentences.

3.5 Defining Goals and Objectives

Once the needs are sorted out, a sound strategy must be crafted (Miller & Hobbs, 2005). While needs can then be formulated as vision and mission statements, they are not enough to operationalize the portfolio. However, there is also a wide gap between the mission and the strategy. That is the reason why they must be first turned into goals and specific objectives.

Goals are usually more generic and might not be measurable. Instead, objectives should be formulated based on goals to be quantifiable, and an evaluation can tell if they have been achieved or not (Wasserman & Czarnecki, 2014). When aggregated, objectives can indicate whether predefined goals have been met. To that end, Doran (1981) recommends goals to be SMART, i.e., specific, measurable, achievable, relevant, and time-related.

Having clear and well-defined goals and objectives is paramount when crafting lower-level strategies such as the INFPRO portfolio strategy. The INFPRO portfolio strategy is not a stand-alone strategy but a derivative strategy to achieve the defined goals and objectives. In fact, all projects should be about strategy execution (Serra, 2017). If the goals change, objectives should be adapted accordingly and strategies updated.

3.6 Creating a Strategy for the Portfolio

Finally, goals and objectives are turned into a strategy. Goals and objectives can be achieved in different ways, and each of them is a potential strategy. The portfolio's strategy must be clear, affecting all the tactical and operational decisions (Wasserman & Czarnecki, 2014).

A strategy also affects the selection of projects within a portfolio, and even before that, a strategy generates a portfolio. As a matter of fact, only once the strategy is clear and well-defined can potential projects be brainstormed and added to a portfolio, waiting to be prioritized (Project Management Institute, 2014).

3.7 Benefits Realization Management

Benefits are measurable and quantifiable improvements that justify the investment (Serra, 2017). According to this definition, when objectives are properly defined, they can be measured and quantified. Thus, they can be considered benefits. It is of paramount importance that benefits are not the projects or portfolio output. In fact, outputs – the actual product of the project – can create changes, i.e., outcomes, that result in benefits for the nation and the community. When benefits are collected, they become value that closes the gap with the country's strategic objectives (Serra, 2017; Serra & Kunc, 2015). Figure 6 in the appendix shows the relationships between outputs, outcomes, benefits, and strategic objectives.

Benefits Realization Management (BRM) is "a set of practices that positively influences project success on the creation of value to the business [or community] and therefore positively influences the successful execution of business [or national] strategies" (Serra, 2017; Serra & Kunc, 2015). The main idea of BRM is that benefits should not be left unmanaged but instead planned, realized, and measured iteratively. This is the case also with the INFPRO portfolio.

3.7.1 Planning Benefits

Serra (2017) indicates planning benefits as BRM's first step after establishing the right environment. Planning benefits encompasses identifying benefits, mapping benefits and their dependencies, classifying benefits (e.g., financial, quality, disbenefits, tangible, and intangible), setting measures and targets, defining ownership, and creating benefits profiles. Mapping benefits requires both a top-down and a bottom-up approach to find dependencies (Serra, 2017).

Overall, it is essential to include benefits from all the sustainability dimensions. Sustainable benefits contribute to the creation of sustainable value. Thus, planned sustainable benefits should close the gap with the long-term strategic objectives stated in the previous strategy-creation steps. The projects that have to be included in the portfolio should contribute to the planned benefits even if they do not directly create benefits. In fact, planned benefits should include both intermediate and end benefits (Serra & Kunc, 2015).

When planning benefits, it is essential to gauge when the benefits are realized. Megaproject benefits can take a significant amount of time, and the time between the initial idea and the realization of benefits can be a deciding factor in selecting projects (Eskerod & Ang, 2017). Moreover, in planning for future benefits, it is important to consider that some sustainable goals in different projects might be conflicting, requiring a trade-off like environmental quality and efficiency (van Gestel et al., 2008). However, trade-offs can enhance the chances of innovativeness – such as an innovative design or using the latest technologies in construction (van Gestel et al., 2008).

Among the benefits, the government should include social impacts. While benefits in that sustainability dimension are difficult to measure, they are experienced by stakeholders and are crucial for portfolio success. Social value should include processes, change, and consequences (Zamojska & Próchniak, 2017).

3.7.2 Realizing Benefits

INFPROs use many resources, and they must bring benefits (Eskerod & Ang, 2017). While planning benefits is already a good starting point, benefits must also be realized.

Benefits should be intentionally sought and prioritized over outputs. To that end, the portfolio requires a benefits realization strategy for every project. The strategy will define how to manage the benefits realization processes. In particular, there will be indications on how to identify and define benefits at a project or program level, their links with the strategic outcomes, and define the responsible institutions. In fact, different players take care of delivering benefits, measurement, recording, and tracking progress methodologies, establishing relationships between initiatives, and delivering change based on them (in the case of programs) (Serra, 2017).

During benefits realization, there are benefits risks such as disbenefits and handover strategies. Uncertainty, especially in INFPROs and the portfolio, requires sound risk management, emphasizing potential changes to the planned benefits (Serra, 2017). To that end, transitions must be carefully managed, as well as the project closeout. At the same time, benefits realization has stakeholders as the project itself, and it may be required to have a separate Benefit Stakeholder Engagement Plan (Serra, 2017).

3.7.3 Reviewing and Measuring Benefits

Benefits should be assessed periodically at the portfolio and the project levels using the metrics defined in the benefits planning step. However, that is not enough. Engaging

stakeholders in terms of awareness, alignment, and support should be a priority. Overall, the most crucial review is related to the alignment of the benefits with the strategic objectives and the alignment of the whole portfolio with the goals and objectives (Serra, 2017).

In the case of INFPROs, success is increasingly weighted based on stakeholder expectations, particularly social and environmental expectations of stakeholders. These expectations make the measurement of success more complex (Zamojska & Próchniak, 2017). Generally, stakeholder influence is relevant for creating value, but the public nature of INFPROs makes them even more subject to such impact (Vuorinen & Martinsuo, 2019). In such cases, value is functional and experiential – cognitive and emotional– and derives from the stakeholders' different views (Chang et al., 2013). To that end, it is central to recognize the social and cultural aspects and conduct a thorough formulation of the country's needs.

3.8 Call for Projects

Analyzing a problem is the first step of a megaproject's life cycle, according to Priemus (2010). However, if the INFPROs are not stand-alone projects but inserted into a larger, dynamic set of projects and their product's operations. The list of problems to solve in order to create value and satisfy needs is the starting point to call for projects.

The government should collect project ideas as it does for needs, involving all kinds of stakeholders, from public agencies to individuals. Politicians can also propose projects, but openness to stakeholders enables democratic management. While political support is important, the political sublime of megaprojects might indicate that some proposals are just for personal interests.

As for needs, it is crucial to have a way to continuously collect ideas, as the portfolio is not a static way to manage projects. A portfolio allows for dynamic project prioritization. If new projects are inserted, and the evaluation finds that it is the right moment and the project is paramount for the current situation, it should be undertaken first. The process is based on the strategic goals and objectives, and the way projects contribute to them. In particular, there should be a multi-criteria analysis (MCA) that assesses projects based on their contribution to each objective – each with a different weight – and prioritizes the projects with the highest score (Nowak, 2013).

3.9 Considering Cultural and Geopolitical Aspects

Cultural aspects profoundly modify the approach and techniques for INFPROs management. Hofstede (1984) systematically analyzed differences between cultures on six different dimensions: power distance, individualism (versus collectivism), masculinity (versus femininity), uncertainty avoidance, long-term orientation (versus short-term orientation), and indulgence (versus restraint). Such research helps decision-makers consider relationships with contractors and other stakeholders, as well as the team formation and the general environment where the project takes place. While awareness does not automatically turn into wisdom, decision-makers and the project management team can select the right time, address protests, and craft communication strategies with an additional parameter.

Hofstede's cultural indexes affect infrastructure sustainability. For instance, a low power distance enhances effective leadership and contributes to the environmental dimension of sustainability. Individualism and low masculinity increase quality of life. Moreover, high uncertainty avoidance contributes to environmental concerns (Meng et al., 2016; Meng et al., 2018).

Cultural aspects affect several areas of INFPRO management. (Naor et al., 2008) found a relationship between culture and infrastructure quality. Mok et al. (2015) suggest that stakeholder management – which is paramount in INFPROs management – is deeply influenced by cultural aspects. Fabianski (2017) adds that governance must adapt to the national culture. Kaminsky (2018) found that culture is among the factors that affect private financing and, ultimately, the success of the procurement method.

Cultural aspects also contribute to accepting new technologies in the infrastructure and, potentially, the infrastructure itself. In fact, Heales (2004) states that cultural dimensions influence the intention to adopt the new solution, influencing the perceived usefulness and ease of use.

Culture categorizations – particularly the dynamic models – can even predict the level of infrastructure growth. Different cultural characteristics indicate whether a nation is prone to implementing more INFPROs (Mayfield & Mayfield, 2012).

Geopolitics is often a reason for implementing megaprojects (Plyaskina & Kharitonova, 2013; Reboredo, 2020). On the other hand, they are dependent on the current geopolitical situation. For instance, it influences the analysis of the environment in which the INFPRO is

implemented. Geopolitical factors like price competition, competitive environment, and demand for natural resources – including oil – influence decisions when included in analyses. Moreover, geopolitics is crucial for scenario analysis (Plyaskina & Kharitonova, 2013).

3.10 A Public Portfolio Management Office (PMO)

A Portfolio Management Office (PMO) is defined as an organization that "coordinates the management of its assigned portfolio components. The responsibilities of a management office can include the following: provide project or program support functions, manage day-to-day operations of the system or systems that support portfolio management, and resource and directly manage a portfolio component or category of portfolio components" (Project Management Institute, 2014). Considering the variety and number of projects, programs, and operations within the portfolio, the author recommends the creation of a nationwide PMO or adapting an existing institution.

A PMO allows for knowledge sharing among projects within the same portfolio. Since it is difficult to share knowledge between entirely different teams from different projects at different times, a mechanism to improve is needed. Organizational learning is an integral part of improving performance. It should be noted that there is intra-organizational learning, but also inter-organizational learning (Chang et al., 2013). In fact, working with several contractors allows for the internalization by the government of their lessons learned that can be shared in future projects. Such consideration is almost impossible without a central institution that collects and shares such knowledge.

A PMO can create and use a historical database for procurement methods, best practices, and lessons learned. It can also standardize – and gradually improve – standards for the procurement process and contract documentation (Kwak et al., 2009).

The concept of a nationwide PMO is not new. Australia is a strong example as it has an INFPROs coordinating authority that acts as a center of excellence, a synonym of PMO (Liu et al., 2016). Other countries have also created centers of excellence to strengthen the institutional quality with solid governance and a low degree of unilateral changes from the government when there are partnerships with the private sector (Iossa & Martimort, 2015).

4. Tactical Level

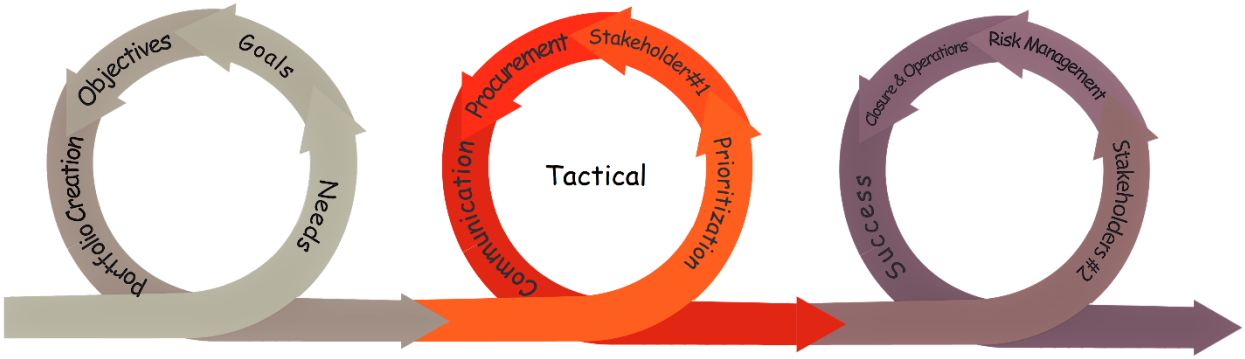

Figure 3 - INFPRO Framework, Highlight on the Tactical Level

Once the government sets goals, objectives, portfolio strategy, and makes other high-level decisions, it is time to decide the strategies for the tactical level and select one or more projects to be executed. Familiarity with the general INFPRO environment allows a better understanding of the problems and is conducive to choosing the approach. This chapter begins with a description of the INFPRO environment. It then describes different approaches and techniques to selecting the right project at the right time, and the approach with stakeholders – including possible protests and movements. The level ends with selecting the procurement method, including contract and contractor management, and communication management. Finally, general principles for contract and contractor management, governance and ethics, and early wins are presented. The latter topics span throughout the whole tactical and operational level.

4.1 General INFPROs Environment

Several notions characterize the INFPROs environment. Given the project's magnitude in terms of size, scope, and influence, the INFPROs environment differs from other projects. The government and contractors should decide the operational strategies based on such an environment.

4.1.1 INFPROs Approach Types

van den Ende and van Marrewijk (2019) point to three different approaches to INFPROs: administrative, technocratic, and humanistic. The first approach sees the government authorities leading the project from the investment to the plans, with a tendency to emphasize the economic aspects and demonstrate a poor interest in the community and its needs. The technocratic

approach leaves decisions to the technical figures like engineers and subject matter experts that focus on innovation and technical aspects, leaving the community unheard. Finally, the humanistic approach is focused on the community actors and interests and sees projects as rooted in social interactions (van den Ende & van Marrewijk, 2019).

Historically, administrative and technocratic approaches did not perform well, while the humanistic approach seems to be more effective. However, a balance of the three is needed. Institutional work is crucial and required, including not only economic and technical but also social and cultural impacts.

The resulting approach should be focused on managing uncertainty. That is the case because megaprojects face unforeseeable uncertainty and many unthinkable events. There are two lower-level typical approaches, namely, trial-and-error and perfectionism. Sommer et al. (2008) presented a table that indicates when to choose either approach based on complexity and unforeseeable uncertainty (see Figure 3 in Sommer et al. (2008)).

4.1.2 Political Support

Given the national interest that INFPROs raise, it is fundamental to have politicians support INFPROs as it increases the chances of project acceptance and funding (Kwak et al., 2009; Orueta & Fainstein, 2008; Osei-Kyei & Chan, 2015). It is no coincidence that the stronger megaproject sponsors have displayed political and negotiating skills (Miller & Hobbs, 2005). A project must be approved only if politicians are fully committed. In fact, several studies of Australian INFPROs show that there can be inefficiencies related to lack of commitment. On the other hand, the study presents that seeking political support can cause long project pipelines that are sources of inefficiencies (Liu et al., 2016). Lack of political support is among the main megaprojects' risks (Boateng et al., 2015). On the other hand, when politicians support the megaproject, several fast-tracks can enhance project and project management success (Ballard et al., 2017). Nonetheless, political support should not become a reason for not conducting analyses or evaluating alternative solutions. That includes situations where bidding costs (see the Procurement Method section) are not reimbursed, or the whole bidding process is ignored (Priemus, 2010).

Decision-makers should consider that INFPROs' life cycle and their product operations will span through many administrations and political changes, which are a threat as they are a source of risks and uncertainty. This is the case of the Corridor for Freedom Project in

Johannesburg, South Africa. In 2016, the administration changed and, even though the new party had already announced project approval, the level of support was unknown (Ballard et al., 2017). There is no one-size-fits-all solution to this problem, but awareness is essential to be prepared. Depoliticization is not a solution as attempts have already been made, but they did not create the desired effects (Giezen, 2012; Miller & Hobbs, 2005; Priemus, 2010).

Political support can be defined in several ways. Brookes and Locatelli (2015) mention that the support of the national government can be the presence of official documents, incentives, or subsidies, or direct financial support. Instead, the support of the local government follows the first definition, but is applied to a local level. It should be noted that political support can be present for just one of the project options for the same goal – for instance, a different route for the same underground (Giezen, 2013).

A striking example of the importance of political support is Boston's Central Artery project, also referred to as Boston's Big Dig. While the project's planning phase started in 1982 and studies had been done, the then-current president of the U.S. vetoed the project because he deemed it too expensive. Such a decision arrived after years of lobbying for federal funds and the approval of Congress. It was only in 1991 that the project could start after Congress overrode the veto (McNichol & Ryan, 2002). The case of Boston's Big Dig shows the importance of involving all the political stakeholders as their support is crucial.

It should be noted that decision-makers often try to gain political support by presenting tampered reports and figures (Rothengatter, 2019). While support is vital, promoters should not earn it using strategic misrepresentation.

4.1.3 Contested Information

INFPROs are highly information-sensitive projects, and no proper decision-making can be done without the correct information. However, some projects are insensitive to information, and the poorness of cost-benefit analyses (CBAs) showcases it. There are personal interests in keeping costs low. The problem of information in megaprojects is that it can rarely be defined as simple truth. Some even say that the right information does not exist, which justifies every view despite the information. However, in such a framework, lies or misrepresentations are not considered (Bruijn & Leijten, 2007). INFPROs exist in an environment of contested information, where political and nonpolitical parties can contest any piece of information.

In megaprojects, data, collection models, system boundaries (for instance, to what geographical extent benefits should be considered), and optimizations can be questioned because nothing is defined, and different variables can affect the results (Bruijn & Leijten, 2007; Teigland, 1999). Moreover, normative standards are also often fuzzy as there can be trade-offs when analyses are undertaken. For instance, a project might reduce the environmental impact but require resources in scarcity to be made. Trade-offs are present even between different analyses. For instance, when different analyses' outcomes must be weighted (Bruijn & Leijten, 2007).

Bruijn and Leijten (2007) highlight how in such an environment of uncertainty, all information in megaprojects is contested as it is not objective or in limited supply. Political parties can contest any information because of its lack of objectivity. The more politicized a project is, the more information will be contested.

One might argue that the government accumulates information, but it is an unfounded assumption that additional analyses will eventually find the correct information. In fact, such an approach would generate an analyses war, and it is unrealistic to think that a new report will find a solution when several previous reports did not. Instead, parties should define a precise method for the analyses in advance and accept the results. Acceptance increases if the other political parties have participated in the analysis and there is "negotiated knowledge" due to interactive rationality. Perks of this approach include increased sensitivity to other views. The larger the consensus, the less the contestation (Bruijn & Leijten, 2007; Priemus, 2010).

4.1.4 Lock-In Effect

One of the common challenges in megaprojects is the so-called lock-in effect. It can be defined as an "escalating commitment of decision-makers to an ineffective course of action (Cantarelli et al., 2010). When lock-in is present, sub-optimal policies are used because of the dependency on the previously defined path instead of evaluating potential better alternatives. The problem is that overcommitment prevents the decision-makers from choosing a better solution, which leads to lock-in. While early commitment to a particular path is not dangerous per se, it can hinder the progress later on (Cantarelli et al., 2010).

It should be noted that lock-in can be either conscious or unconscious. It can be intentional – in order to continue a project – or unintentional. It can emerge at a very early stage during the decision-making and at the project level, but it will remain during the whole decision-making process and project phases (Cantarelli et al., 2010).

Lock-in can negatively affect the project performance in terms of methods for calculating cost overruns. For instance, cost overruns should not need to be calculated against the moment when the project has been approved but rather against the budgeted cost at a later stage in the decision-making process. Moreover, lock-in can have an influence at a project level because the choice to implement the project has been made, but the way to do it has not (Cantarelli et al., 2010). Another typical behavior is the so-called escalating commitment, where the decision-maker tries to "save their face" and find a justification by escalating (Cantarelli et al., 2010).

Lock-in can be identified at the decision-making level using indicators such as inflexibility and closure to alternatives. Scholars have also detected several factors that can lead to lock-in, including sunk costs. Sunk costs are one of the most common in megaprojects. Due to the loss aversion bias, a loss of a certain amount is considered more relevant than a gain of the same amount. Therefore, decision-makers find themselves bound to the past choice when there are sunk costs (Cantarelli et al., 2010).

In terms of policies, setting the moment in which the decision-makers decide that the project will be built is essential for cost overruns calculation. Additionally, intentional lock-in must be prevented, allowing decision-makers to welcome other solutions and make an optimal decision (Cantarelli et al., 2010).

The cases of the Betuweroute and the High-Speed Link-South projects in the Netherlands show how lock-in hindered the project and influenced cost overruns on both the decision-making and project levels (Cantarelli et al., 2010).

4.1.5 Decision-Making and Leadership

INFPROs require a well-defined decision-making team and, most importantly, a sound decision-making approach. Decision-making is present in several aspects of the INFPRO portfolio, from strategy selection to project management. Alignment among the different decision-makers will reduce potential contrasts.

Starting with Project Management, Giezen (2012) states that approaches to megaprojects vary and span from a more closed approach like in engineering – the classic predict-and-control – to an uncertainty-accepting model – prepare-and-commit. Given the high level of uncertainty in megaprojects, approaches leaning towards the latter are suitable for most cases.

A threat for decision-makers is the several biases that might affect their judgment. Indeed, they are magnified because of the magnitude of the decisions. For instance, a relevant

shortcoming in the decision-making process is that managers often make decisions under the "illusion of control bias" due to overconfidence, while outcomes are, in fact, the result of chance. Such adverse effects are amplified as uncertainty increases (Kardes et al., 2013). Additionally, high sunk costs lead decision-makers to avoid losses even if the gains are much less. Therefore, there is a point of no return when investing. These biases are called the "sunk cost effect" and the "prospect theory" (Flyvbjerg, 2017; Kardes et al., 2013). Finally, the self-justification theory also explains the tendency to stick with the previously made decisions. For all these reasons, megaprojects are rarely canceled (Kardes et al., 2013).

In order to cope with the biases above, scholars support incremental decision-making that recognizes the importance of modifying plans based on trial-and-error. However, that does not indicate that the design and building of infrastructures can be concurrent, as it is recognized as a hindering technique because it increases the changes of subsequent design modifications (Genus, 1997). Incrementality is even more important as there is no space for inflexibility in INFPROs as it creates costs and time overruns. Inflexibility is the result of centralized decision-making that does not consider stakeholders (Genus, 1997). Instead of supporting inflexibility, managers should learn to handle exceptions better as they emerge (Orr & Scott, 2008). In fact, megaprojects require that strategies adapt as new details emerge, and no single strategy results in better outcomes (Miller & Hobbs, 2005). That is also why this framework includes cycles and both an early and a late stakeholder involvement step.

When considering inflexibility, the case of the Channel Tunnel between France and England is a case in point. The project had no less than four evident characteristics of inflexibility, namely, it was highly capital intensive, had a long lead time, high unit size, and a need for specialized and dedicated infrastructure (Genus, 1997).

Inflexibility is not the only problem. The aforementioned sublimes might lead decision-makers to lean toward the most innovative, aesthetically pleasing, and technically complex solution. However, decision-makers should recognize that it might lead to failure. To avoid that, there are some philosophies that they can follow. KISS (Keep it Simple Stupid) is one of them. It prescribes that decision-makers keep the projects or engineering designs more manageable whenever possible. It should be noted that KISS seeks simplicity - described as the reduction of complexity – but it can come at the expense of the richness of the design (Giezen, 2012). For instance, the Beneluxlijn project – that extended Amsterdam's subway – followed such a

philosophy. One of the applications was deciding not to build underground as it was possible not to do so, avoiding additional risks and uncertainty (Giezen, 2012). KISS allows project teams to maintain uncertainty within a manageable domain, addressing optimism bias and strategic misrepresentation (Giezen, 2012). Undeniably, there are downsides, but when the project is relatively straightforward, and no particular innovation is needed, it is an excellent approach to avoid the technological sublime trap (Giezen, 2012).

The so-called sensemaking is an additional problem as decision-makers try to rationalize choices they want to make – this is, in fact, a human bias. Such a tendency is at work when they try to solve complex problems like INFPROs. Other factors that influence the decision-making process include experience, normative, and other influences.

Adding to the complexity, megaprojects can be global, cross-border, or cross-regional. Managers must recognize that moving outside their cultural cognitive code is complex as something that might seem rational and logical in a context might not be the same in all regions. Therefore, managers should recognize what aspects of their behavior are purely cultural and can be modified and what is instead close to the moral core that cannot change. (Orr & Scott, 2008).

In this context, leadership becomes an essential factor for sustainability, but with all the obstacles mentioned above. In general, leaders are not just managers, as leadership is described as the process of influencing. Thus, stakeholders can be leaders as well. Authentic leadership, ethical leadership, and transformational leadership have directly or indirectly been linked to corporate social responsibility (CSR), which can be translated into sustainable development in the public context. On the other hand, an autocratic leadership style does not seem to be conducive to sustainability. Because of the complexity and uncertainty, Metcalf and Benn (2013) propose a shared leadership and sensemaking approach to leadership, which enhances the CSR (sustainable development) performance. Additionally, complexity leadership – which enables the future instead of addressing it – promises good results in a complex environment like CSR (sustainable development). It does not encourage convergence as it considers the system's complexity (Metcalf & Benn, 2013).

Sustainability is complex. However, there is complexity even in decision-making and leadership. Therefore, leadership for sustainability requires exceptional capabilities. Leaders must read and predict through complexity, think through complex problems, engage groups in the dynamic environment and organization, and be emotionally intelligent. They will need to link

the external complexity to the internal organization to solve already complex problems like INFPROs and include sustainability (Metcalf & Benn, 2013).

4.1.6 System Thinking

In INFPROs, it is not helpful to address a specific point to solve an issue. In fact, megaprojects are open and dynamic systems (Ahiaga-Dagbui et al., 2017). Different parts influence each other. Therefore, a systematic study is needed to identify causes as a system is more than the sum of its factors. The same outcome can be reached from different initial states and following different paths in an open system. Such a concept applies to risk management, cost management, and stakeholder management (Ahiaga-Dagbui et al., 2017).

Such an approach to megaprojects should not discourage the study of common factors that influence success and problems. In fact, while some factors might not be causal, it is important to recognize correlation. At the same time, a few low-correlation factors might cause success or issues in INFPROs (Ahiaga-Dagbui et al., 2017).

Three tools can be used to support system thinking:

- retrospective sensemaking seeks information, attribution of meaning, and action through information sharing in a collaborative environment. It helps to develop meaning in complex systems like megaprojects;
- cognitive mapping (CM) is a set of tools to make sense of accounts of problems through mental schemes; and
- system dynamics (SD) that allows a schematization of causes and effects in highly dynamic and complex systems.

Such tools can be combined to create networks and connections between factors rather than ranking possible factors (Ahiaga-Dagbui et al., 2017).

4.1.7 Modularity and Speed

As mentioned in the previous subsections, incremental decision-making is suitable for INFPROs. It is possible to expand on that by noticing that modularity can be conducive to successful infrastructure development. Dividing INFPROs into various modules to decide different parts and topics like the position, pollution, and landscape allows flexibility even if the result is suboptimal. Modularity allows exploiting up-to-date knowledge that comes with time (Priemus, 2010). Indeed, megaprojects suffer from indeterminacy, i.e., some stakeholders,

interests, and issues are initially unknown (Miller & Hobbs, 2005). Therefore, modularity can be an appropriate INFPRO management approach.

According to Flyvbjerg (2021b), repeatable modularity and iteration speed are two critical factors influencing megaproject success. They allow the organization to learn rapidly and scale up quickly from small size pieces to megaprojects. In fact, the monolith approach creates problems because of the specificity of infrastructures. It should be noted that big and scalable are different. When big is forced for something better achievable with something scalable, fragility arises. As aforementioned, megaprojects are systems, and they are complex. Therefore, minor errors can magnify in the system if not blocked from the beginning (Flyvbjerg, 2017).

Modularity opens to scale tailoring, as opposed to the traditional predetermined scale. That way, decision-makers can evaluate new technologies early during construction. Furthermore, the speed resulting from modularity improves the performance as it addresses the limited time horizon of certainty that often hinders project execution. Additionally, modularity enables iterations that create a feedback loop to improve the delivery of the next module through learning-by-doing. Thus, it also enables experimentation. Some might argue that a problem of such an iterative and fast approach is that some projects are non-scalable. In fact, scalability is not binary but a degree (Flyvbjerg, 2021b).

Managers should note that negative learning is possible when modularity increases the knowledge of obstacles and project duration. If that is the case, it just means that the project could not be done faster because of the uniqueness of the problem, and a different solution may be a wiser option (Flyvbjerg, 2021b).

An example of the importance of modularity and speed is Madrid's new subway. It was built with a cut-and-cover construction method, avoiding problems and risks due to customization – e.g., signature architecture – and other types of non-value-adding innovation. Innovation did not disappear, but it was included by combining existing products and processes in a new way. The schedule was shortened as much as possible, minding additional risks due to the time span. Tunnel modules were made iteratively, with teams competing with each other, enabling learning and knowledge transfer. Eventually, the project was completed in half the time at half the cost (Flyvbjerg, 2021b).

4.1.8 Megaproject Life Cycle

INFPROs are a subset of megaprojects and follow the megaproject life cycle and the general trend. Megaprojects as a category experience a visible pattern, i.e., emerge-surge-purge. New technologies diffuse from and to local, national, regional, and even international areas with cycles of around 20 years. Contributing factors include corporate globalization, modern mass communication technologies, and increased ease of international travel. Thus, infrastructure projects follow the S curve of innovation. That means that political, efficiency-related, and symbolic reason factors make them old, and something new is created (Flyvbjerg, 2017).

Priemus (2010) proposed a five-stage conceptualization of the process of managing a megaproject: (1) problem analysis; (2) compilation of a functional program of requirements; (3) elaboration of the technical, practical, and economic aspects and preparation of the project until it is ready for execution; (4) realization of the project; and (5) the operation of the infrastructure after completion (Fahri et al., 2015).

Scholars widely accept this model of the megaproject life cycle. However, modifications have been suggested. Fahri et al. (2015) point that an additional phase can help broaden the view and focus on value, i.e., the post-project evaluation. As a matter of fact, project success can be better gauged after the project conclusion. This concept is expanded in the Operational Level chapter.

Priemus (2010) additionally recommends a phase-gate structure, remarking that a "no go" decision is acceptable if the phase is not finished yet because there is no room for re-work in case of "go". However, Flyvbjerg (2017) opposes such a structure and suggests that stage-gate leads to project inflexibility. In fact, the suggested approach, namely modularity, is enough to cope with uncertainty and experiment before scaling.

4.1.9 Knowledge Management

Knowledge Management (KM) and Knowledge Transfer (KT) are essential for increasing effectiveness and fostering innovation. As information becomes more complex and fragmented, KM grows in importance in INFPROs. Moreover, megaprojects are temporary organizations, and knowledge remains with the individuals if not transferred (Aerts et al., 2017). Additionally, managing project knowledge becomes crucial in sustainable project management (SPM) as knowledge becomes the resource to develop sustainable business practices (Moehler et al., 2018).

Accumulating knowledge, especially regarding procurement methods involving the private sector, helps countries successfully initiate, implement, and complete INFPROs. This is true even if the infrastructure is more complex, irrespective of the financing nature. Some players also develop experience in coordinating such projects, which is crucial for large projects like infrastructure development. For instance, KT invites making more strategic choices in the design. It is crucial to extend KM to the private sector when involved (Aerts et al., 2017).

It should be noted that KT is not free but instead requires investments because it does not entail a mere copy-paste (Aerts et al., 2017). KT can include additional meetings, reports, information systems, lessons learned databases, and consulting efforts by previously employed resources. Aerts et al. (2017) state that the best KT tools are training, reporting to a superior, and personal documentation. Moreover, interpersonal KT is also essential. It is a mistake when managers find themselves outside their comfort zone with public-private partnerships (PPPs), they do not value previous knowledge (Aerts et al., 2017).

Knowledge redundancy is a tool that enables choosing the best options or simply having a better view of the problem. As additional people participate in meetings, uncertainty is reduced. This concept might sound preposterous as the abundance of decision-makers can cause deadlock. However, it proved beneficial because it keeps alternatives and options open, and they are essential in dealing with complexity (Priemus et al., 2013).

External knowledge is also essential. For instance, consulting firms can help share knowledge across INFPROs. Nonetheless, external knowledge is rarely internalized, which might increase costs and result in less effectiveness. The state-owned enterprise can have a corporate culture in terms of simulating PPP structures and fostering lessons learned. Indeed, PPPs can help share knowledge in different projects (Aerts et al., 2017).

The temporary essence of megaprojects does not support KM and KT (Aerts et al., 2017). However, when an INFPRO is inserted within a portfolio context, the PMO can perform this function, becoming a success factor. In fact, in companies, a PMO can take care of knowledge sharing within projects, across projects, social practices, and quality management (Moehler et al., 2018). As for companies, a nationwide PMO can perform the same activities for the INFPRO portfolio.

The case of a rail project to connect the two sides of river Scheldt in Northern Europe highlights how even the knowledge of a different type of project can be contextualized and used

to improve the performance. In fact, it used the knowledge of a previous project to connect cities with their airports via railways (Aerts et al., 2017).

4.2 Selecting the Right Projects at the Right Time

Once there are several potential projects in the portfolio – derived from the call for projects of the strategic phase, it is important to prioritize them by selecting the INFPRO(s) at the right time. This is especially important considering that there is limited money and resources to commence all the initiatives (Bristow & Nellthorp, 2000; Priemus, 2010).

Prioritizing a project is not a straightforward task. For instance, the EU has an appraisal method to prioritize projects in the program, choosing between different options for the same problem, whether a particular project delivers value for money (VfM), and the optimal time (Bristow & Nellthorp, 2000).

In the following sections, the author presents several considerations and tools to assess the project's priority. However, they must have a life cycle perspective. In fact, it is essential not to focus just on the project itself but also on its product, i.e., the infrastructure (Artto et al., 2001).

4.2.1 Stakeholder Value

Every project, including megaprojects and INFPROs, must bring value to both the project initiator and the stakeholders (Eskerod et al., 2018). In general, value is defined as the sum of benefits minus the sum of costs, but there is a need to understand the concept further as multiple views of benefits and costs are included in the definition (Eskerod et al., 2018). In general, public infrastructure projects should seek the so-called stakeholder value.

Table 1 below summarizes different categorizations of stakeholder value and benefits.

Article(s)	Type	Categories
Eskerod and Ang (2017); Eskerod et al. (2018); Harrison and Wicks (2013)	Stakeholder value	(1) stakeholder utility associated with actual goods and services, (2) stakeholder utility associated with organization justice, (3) stakeholder utility from affiliation, and (4) stakeholder utility associated with perceived opportunity cost
Eskerod et al. (2018)	Nature of benefits	(1) relativistic or contextual, (2) tangible or intangible, (3) hard or soft benefits, and (4) subjective

Article(s)	Type	Categories
Eskerod et al. (2018)	Realms of value	(1) preplanned, (2) unexpected (unforeseen), (3) emergent, (4) serendipitous, (5) positive (benefits) or negative (disbenefits)
Ang et al. (2016)	Perspectives of value	(1) singular/transactional value, (2) generative value, (3) transformational value, (4) a value spectrum, (5) retrospective-reflective-future oriented value, (6) value networks and relationships, and (7) personal reward

Table 1 – Stakeholder Value Categorizations

Furthermore, the concept of the unexpected or unforeseen value and benefits is of much relevance. Such value can be realized by exploiting the so-called project value opportunities (Lechler et al., 2013). This concept will be expanded in the Operational Level chapter.

In planning for stakeholder value, it is possible to use the table developed by Eskerod and Ang (2017) that describes an example of the importance that different types of stakeholders give to the different types of stakeholder value. Nonetheless, value in megaprojects can be realized much after the project ideation. Consequently, decision-makers and auditors must assess and consider the time between the project ideation and the potential benefits realization as a factor in the project selection (Eskerod & Ang, 2017).

An essential aspect of creating stakeholder value is equality of the cost-benefit ratio. The opposite can cause frustration and dissatisfaction. The Massachusetts Turnpike highway case is an example. It requires commuters from the North Shore to pay tolls, while it is toll-free for commuters from the South Shore. This discrepancy is related to an integration problem with the state's other highways that do not require tolls. Therefore, there is inequality in cost distribution that creates dissatisfaction in consumers (Jacoby, 2021). To that end, it is essential to recognize whether the project might create inequality and find different solutions that can solve the impairment or shift the focus on a different project.

4.2.2 Value Assessment Tools

There are several tools to compare and prioritize projects. Such tools are tailored for larger projects such as INFPROs. However, many of them require some modifications to consider sustainability and other peculiarities of INFPROs.

The cost-benefit analysis (CBA) is one of the most used tools, and it is often used to compare the general situation where the project is not implemented with the alternative of implementing the project. CBAs attempt to include all the relevant effects on the different segments of the society using monetary values without double-counting benefits and producing one single number as output to perform comparisons (Bristow & Nellthorp, 2000; Jones et al., 2014; Sturup, 2009).

However, CBAs present several weaknesses such as the decision-making process, the monetization of non-market goods, unaccounted equity, openness of results interpretation, public scrutiny, need for completeness and correctness, difficulty of understanding, ethics, use of general indicators when specific ones are needed, lack of attention to the (dis)benefits, assumption that the financial parts do not influence, and discounting long-term environmental consequences. Most importantly, the CBA is very sensitive to the starting assumptions, e.g., amount of traffic, discount rate, and safety. Wrong assumptions – which can change during the project – can result in a positive CBA final value even if the actual one would be negative (Jones et al., 2014; Priemus, 2010; Rothengatter, 2008).

Flyvbjerg (2021a) and his team analyzed 2062 public investment projects in 104 countries across six continents from 1927 to 2013 to assess the goodness of CBAs. They found that both cost estimates and benefits estimates were often wrong. Average cost overruns go from 24% for roads to 85% for dams considering real terms. Benefits estimates are less biased than costs but still present shortfalls of 58% for bus rapid transit, 34% for rails, and reasonably accurate estimates for bridges, buildings, power plants, and roads. Therefore, benefits overruns do not compensate for cost overruns but rather the opposite. Such inaccuracy did not show signs of improvement over time. Bias in CBAs leads to resource misallocation, which is the primary purpose of CBAs (Flyvbjerg, 2021a). In fact, Florio and Vignetti (2005) highlighted how it happened that funds in the EU have often not been allocated according to CBAs. Overall, the cost-benefit ratio is overestimated between 50% and 200%, with only a light influence of the type, geography, and historical time of the INFPRO (Flyvbjerg, 2021a). CBA is not reliable because it includes both the poor cost forecast and the poor benefit estimation performance. Since they are put together in one analysis, there is a second-degree inaccuracy (Flyvbjerg, 2006, 2008). The so-called CBA fallacy is addressed later in this thesis.

Despite the problems of CBAs, most EU member states used it as an appraisal method. CBAs only consider the benefits of undertaking the project against the alternative of maintaining the status quo. Alternative uses of the money are not considered. CBA also does not consider some externalities like the environment. Technical difficulties in accounting for indirect benefits and costs are not enough to explain the cost overruns, but other factors exist. Supplemental quantitative and qualitative appraisals are often included to cope with the absence of factors that are not monetized because of technical or political reasons (Bristow & Nellthorp, 2000; Sturup, 2009).

A complementary tool for value assessment is the project's Residual Value (RV), often overlooked in CBAs. RV should be calculated as the discounted cash flow from the beginning of the project to infinity to account for the remaining value of the investment as if it was sold at the end of the time horizon. Instead, decision-makers often use other ways. A direct technique is to calculate the value of the infrastructure after linear depreciation. However, such a method is not comprehensive, and the project length should be shorter than the depreciation period of the asset. Alternatives include evaluating the annuity or perpetuity of benefits minus costs, but they do not include the asset's actual value. Whatever the method, it should be clear for interpretation by the public and economists (Jones et al., 2014).

Different types of projects have different operations life spans. The lifetime is the most important parameter that impacts RV and the net present value (NPV) with the discount rate. If the discount rate is high, the long-term effects – such as the environmental ones and the RV – are minimized. Considering that the lifetime ends when maintenance costs are higher than benefits, the RV is the residual cost of selling the still-usable parts or continual replacement. Therefore, RV is connected to the discount rate and the lifetime. RV can be calculated by separating the different assets of the infrastructure, then using the proper lifetime and a different depreciation function, and a different discount rate (hyperbolic or declining). Lands and other materials like iron must be included in the RV as well (Jones et al., 2014).

Some countries use the multi-criteria analysis (MCA), which often includes a CBA. MCAs are objective-lead frameworks, propose criteria for the achieved objectives and assign a weight to each criterion (Bristow & Nellthorp, 2000). MCAs weigh different cardinal, ordinal, and numerical criteria to find the best solutions. Since CBAs are not reliable but are often used, it

can be suggested to use the CBA as an essential criterion but not as the only one in the final decision.

As aforementioned, CBAs struggle when there are aspects that are difficult to translate into monetary value. While there is a widespread agreement on what sustainability indicators to include (see the following subsection), there is little to no agreement on assigning a monetary value. Moreover, there is no alignment on including indirect impacts (Bristow & Nellthorp, 2000). Overall, there is a need for a standard that includes the triple bottom line, reminding that comparing different CBAs of different projects might not have a meaningful result. Instead, CBAs are used to evaluate whether a project provides more benefits than costs and compare to different alternatives for the same project (see sections below).

Intending to include sustainability dimensions, several modifications to CBAs have emerged. The Social Cost-Benefit Analysis (SCBA) can be used for projects like INFPROs that hugely impact society (Zamojska & Próchniak, 2017). SCBA is calculated accounting for changes in personal utility and the overall social welfare. Practically, those are difficult to measure. However, since different stakeholders have different perceptions of social value, different SCBAs should not be aggregated. Instead, analyses should be conducted separately, considering the SCBA value at different points in time. This should be done without comparing the result of other projects' analyses as it only makes sense case-to-case (Zamojska & Próchniak, 2017).

The traditional Net Present Value (NPV) is a well-known tool to assess the current value of investments. Costs and benefits are discounted over the timespan of the project and the infrastructure operations to have the present value of the project. Nonetheless, while the NPV shows the current value of the capital investment, it overlooks some aspects of sustainability. The Global Footprint Network has developed a modified version, the Net Present Value Plus (NPV+) methodology, that incorporates non-monetary value in the NPV to view the life cycle value of an investment better. It uses scenario analysis – considering scenarios with low availability of resources, high availability, different rates, among others – to choose the best option. NPV+ can help policymakers, and decision-makers maximize long-term wealth and provide realistic guidance. It can also be included in the aforementioned CBA to make it more realistic (Global Footprint Network, 2021).

The NPV+ has been tested, for instance, with an investment in Maryland. It showed that fuel price could increase drastically in the future, as happened in the last ten years – when it tripled. Thus, the investment should be made considering electric vehicles so that the life cycle operation cost will be lower and benefits higher. Additionally, the NPV+ method highlighted how investing in land conservation would bring great value for Maryland, and the investment was recommended (Global Footprint Network, 2021).

A final tool is the System Dynamic Model (SDM) approach. SDM can better suit the needs of megaprojects because of the following characteristics: it is system-based and dynamic; it works sequentially; it can be based on micro behavior; it integrates macro, regional, and sectoral indicators; it provides a closed network; it can be calibrated for different levels; it can be integrated with other models like transportations to estimate the usage of the project better; and it allows for changes in trends because the dominant feedback mechanism can change over time (Rothengatter, 2008).

This section presented several tools that can be used for comparing the value of different projects. All the tools mentioned above present pros and cons and should be used while acknowledging their limitations. Whenever one tool presents too many downsides that cannot be solved, solutions as the MCA can help incorporate different analyses and find the best option(s).

4.2.3 Value Criteria

While tools are essential, the decision criteria are equally crucial. In fact, CBA, RV, NPV, NPV+, MCA, and others calculate their results using criteria. To that end, choosing the right aspects to consider within the decision is paramount. Problems may arise as different projects have different strengths. Overall, criteria should include indicators for the created strategic value to assure alignment with the previously defined goals and objectives and overall sustainability criteria.

While each project might require its criteria, the nature of prioritization requires the evaluation of the projects based on the same set. As aforementioned, criteria must consider strategic value. However, that does not prevent decision-makers from including economic, technical, technological, environmental, policy-related, and life cycle criteria (Scheffran, 2010).

Among criteria, some are long-term oriented and are rarely considered. It is the case, for example, of the ease and utility of maintenance, repair, and rehabilitation (Šelih et al., 2008). If these kinds of works are easy to perform and increase utility, the project must score higher.

Sustainability criteria are difficult to select as there is no convergence in a list of sustainability criteria. However, there are many lists from which the criteria that fit the INFPRO and the country's needs can be drawn, including: the Life Cycle Assessment (LFA), the Global Reporting Initiative (GRI) for companies, the Sustainable Development Goals (SDG) for governments, the WWF "10 one planet living principles for sustainability" for any business (e.g., zero carbon, zero waste, sustainable transport, sustainable materials), and others (Oehlmann, 2010). Overall, many criteria are similar, but the decision-makers must include those aligned with the strategic objectives and weigh them appropriately.

4.2.4 Problems and Solutions for Cost Estimates

Previous sections have stressed the frequency of estimation errors. Both costs and benefits are incorrectly estimated, resulting in second-degree inaccuracy when combined. Given such problems, this subsection highlights causes and identifies solutions for costs, while the next one turns to benefits.

Estimating costs has proved a difficult task in megaprojects. As a matter of fact, they are often underestimated (Flyvbjerg, 2006). Some statistics clearly show the difficulty of managing INFPROs. For instance, nine of ten transport INFPROs experience cost overruns, with average cost escalations of 45% for rails, 34% for fixed links – i.e., tunnels and bridges, and 20% for roads. While it might be common sense to believe that project management performance changes by country or improves over time, that is not the case. The only difference is between developed and developing countries, as the latter experienced more pronounced cost overruns (Flyvbjerg et al., 2004). Such insights are surprising and need to be developed further. In fact, if the calculation errors were random, the mean should be around zero. However, the problem of underestimation of costs is much more pronounced than overestimation, respectively, 86% and 14%. On average, the actual cost exceeds the budget by 20% (Flyvbjerg, Holm, et al., 2003).

The longer the project, the higher the cost escalation in transport INFPROs. Flyvbjerg et al. (2004) found a cost escalation for every year of project implementation, amounting to 4.46% of the total cost. The percentage falls to 3.28% if a specific geographical area is considered, but the base cost overruns – the intercept in the graph – increase. The authors found that the type of transport INFPRO does not affect the cost overrun per year of the implementation phase, and most likely, not even the complexity does. Since the size of the project is steadily increasing, the percentage cost escalation per year of implementation means that the cost escalation in absolute

terms is increasing. Thus, there are additional concerns for cost estimations and potential losses for governments (Flyvbjerg et al., 2004).

Scholars have found systemic reasons why this is the case. Considering that the errors are not random, it is vital to understand the different causes and solutions to cope with them. Different factors can influence forecast inaccuracy: technical, model inaccuracy, and psychological and political-economic factors. Technical causes are likely not contributors because the mean discrepancy between forecast and actual costs is not zero. Model inaccuracy, instead, is to be discarded because there has been no improvement over the years. The latter, instead, explains inaccuracy in terms of optimism bias and strategic misrepresentation. The higher the organizational pressure, the higher misrepresentation, and the lower optimism bias as they complement each other. In fact, estimation errors are often systematic and predictable rather than random. An awareness of the problem does not solve it per se but can help identify situations in which the ordinary faith in one's impression must be suspended. The reason for the errors stands in overconfidence and insufficient regard in distributional information (Bruzelius et al., 2002; Flyvbjerg, 2006, 2008). It should be noted that misrepresentation not only supports non-viable projects but can also ruin careers and lives (Flyvbjerg, 2017).

Flyvbjerg, Holm, et al. (2003) identified an additional factor: during the bidding process, or when presenting the project for approval (in the private sector bidding), the system encourages low forecasts or conservative forecasts estimates. In fact, costs usually are a selection criterion, and misrepresenting them makes the contractor rank better. This factor better explains the reason why there are no differences between geographical areas. CBAs are not reliable also because of such unwanted incentives, and risks are ignored.

What is presented above does not entail that technical difficulties do not exist. In fact, there are several technical challenges, including scope creep and rework, misguided trade-offs between project scope, time, and cost, a poor understanding of the systemic and dynamic nature of projects, and unidentified or improperly managed risk and uncertainty (Ahiaga-Dagbui et al., 2017). The system view is particularly important as it leads to proper risk assessment and cost overruns avoidance. Therefore, causes of cost overruns must not be found but constructed by connecting several system components, as reasons cannot be separated from their environment (Ahiaga-Dagbui et al., 2017).

An essential modification to the initial estimate is the inclusion of sustainability. As it becomes more and more important, the additional cost of planning and scheduling must be accounted for in the indirect costs and schedule (Koke & Moehler, 2019).

Potential solutions can derive from the observation that the forecasting world and, in particular, infrastructure operating costs are stochastic. That means they cannot be determined as in a Newtonian world, but external factors can randomly influence costs outside the cause-effect paradigm – in some cases improving infrastructure increases costs, and other times it decreases them (Bruzelius et al., 2002; Iossa & Martimort, 2015).

Given such discouraging history of cost estimation and the unreliability of estimates, Flyvbjerg, Holm, et al. (2003) recommend approaches that entail increasing transparency, using performance specifications, explicitly formulating regulatory regimes for project development and implementation, and involving private risk capital.

As aforementioned, a system view is essential to acknowledge that a different approach is required. However, it does not solve the problem. In fact, often, project players take an "inside view" of their projects which results in underestimating costs and risks while overestimating benefits. A solution is to take an "outside view", which prevents optimism and overconfidence. Taking the outside view has proved effective in improving the forecasting performance, with an even higher impact for non-routine projects (Flyvbjerg, 2006). "Reference class forecasting" (RCF) is a systematic way to do so (Flyvbjerg, 2006, 2008). RCF was first described by Kahneman and won him the Nobel prize in 2002. It can help overcome the most critical biases in cost – and benefits – estimation. In fact, RCF shows us that these errors are predictable and not random (Flyvbjerg, 2006).

The RCF method can be divided into three steps: (1) identifying a reference class that is large enough to be statistically relevant but narrow enough to be comparable to the project; (2) creating a probability distribution for the reference class that is broad enough to have variety inside; and (3) compare the project to the reference class to find the most likely outcome. If people take an outside view, their estimation performance dramatically increases. RCF hinders human biases and produces better results when projects are non-routine. The only problem is having a megaprojects dataset that allows reference class forecasting (Flyvbjerg, 2006, 2008). RCF is powerful because planners usually ignore distributional information (Flyvbjerg, 2006). Although distributional information is available, often optimism and overconfidence lead

planners to ignore it. It is the case, for instance, of the development of a curriculum for a new subject area in an Israeli high school. Kahnemann, the creator of RCF and one of the project planners, knew that the average timespan was seven years and that up to 40% of the teams did not finish and gave up. Instead, the team estimates ranged between 18 and 30 months and had no extra expertise or tools than the past teams to justify the speed. However, the members ignored the information and eventually finished in eight years (Flyvbjerg, 2006; Lovallo & Kahneman, 2003).

RCF allows increasing the cost estimates (uplift) depending on the acceptable risk level to balance the optimism bias. The lower the acceptable risk for cost overrun (maximum cost overruns), the higher the uplift needed to avoid it. For instance, in the context of highways creation, if the maximum acceptable cost overruns are 20% of the project budget, the capital increase must be 32% to fight optimism bias, according to the database collected by prof. Flyvbjerg and his colleagues (Flyvbjerg, 2008).

While RCF is a powerful instrument to address optimism bias, the problem remains that the political-economical bias or strategic misrepresentation are not honest mistakes, and there are no incentives to improve forecasts because everyone should do it. For instance, in the case of project selection, those projects with lower costs and higher estimates are selected even if they are not accurate. Therefore, managers and forecasters might not be interested in the method (Flyvbjerg, 2006, 2008). Incentives must be changed to allow RCF to be used, including considering its use as due diligence, with forecasters that must be taken accountable to carry the full risks of their forecasts (Flyvbjerg, 2006, 2008). Projects with inflated CBAs should be stopped or placed on hold, and penalties should be applied to those who consistently produce misleading forecasts. This should be more intense the higher the political pressure (Flyvbjerg, 2006).

Overall, CBAs and other tools do not suffer from errors but rather biases. In fact, the main problem is not costs overruns but the initial cost underestimations (Flyvbjerg, 2021a). Flyvbjerg (2021a) presents four recommendations to fix CBAs, namely, systematic and effective de-biasing using RCF, the introduction of skin-in-the-game for forecasters through institutional setup and rewards, independent and politically neutral audits to adjust estimates, and inclusion of non-experts in the decision-making process to make it democratic and merge all concerns.

4.2.5 Problems and Solutions for Benefits Estimates

Forecasting benefits has also proven a difficult task in megaprojects. In fact, they are often overestimated (Flyvbjerg, 2006). While the benefits estimation performance is better than the cost estimation, it is important to reduce the overall inaccuracy (Flyvbjerg, 2021a).

Miscalculating benefits can have dreadful impacts, as shown in the case of the Norwegian Winter Olympics in 1994. It happened that the government was expecting a steep increase in tourism because of the event. Instead, the estimates were far larger than the actual increase, and many hospitality facilities failed due to over-supply. Norway also found itself with extra sports facilities which remained relatively unused. Errors were purposely made to justify the investment, and "expert prostitution" was crucial (Teigland, 1999). Similar benefits miscalculations happened in the case of the soccer 2002's World Cup in Japan (Whitson & Horne, 2006).

The Norwegian case suggests it is crucial to define and limit the influence zone on which benefits are calculated. While past events can give an idea of the cost and benefits, each megaproject is a stand-alone, and past projects can leave an idea of success because of the advertisement of the project promoters (Teigland, 1999). Moreover, decision-makers should consider that benefits – as costs – are also stochastic as even well-planned benefits can be influenced by many factors (Iossa & Martimort, 2015).

Despite the randomness of some benefits, Koke and Moehler (2019) invite to calculate benefits as they extended indefinitely beyond the project end. In fact, INFPROs operations last for decades and mainly create benefits after the project conclusion.

4.2.6 High Uncertainty vs. Low Uncertainty

In prioritizing INFPROs, decision-makers should consider uncertainty. Megaprojects often make use of cutting-edge technologies. That is the case because INFPRO's long life cycle requires the technology to last for long. Considering the speed at which innovation is emerging, new and almost untested technologies are often used, becoming the standard or even the "previous generation" over the life cycle. However, there is a crucial choice to make, as new technologies will most likely produce benefits, but contractors have less experience in using them. In fact, while technologies create several benefits, they are harder to manage and are a source of risks and uncertainty (Giezen, 2012; Priemus, 2010).

Other times, there is no choice whether the innovation is needed. For instance, highly advanced and complex technologies or new materials and equipment might be the only ones that meet the government standards. This situation is among the significant problems stakeholders confront in INFPROs (Mok et al., 2017).

To cope with the technological uncertainty and lower costs, some practitioners even suggest maximizing the standardization of design and building techniques (Beach, 2021). Additionally, some scholars support the idea that a too high level of technological innovativeness prevents using some techniques, such as reference class forecasting (RCF), that improves cost estimates.

In conclusion, projects that require a high level of technological innovativeness should be carefully evaluated, and the difficulty in managing new technologies can become a factor in the decision. Decision-makers must be confident that the contractors can manage such innovation and cope with uncertainty during project execution. Such evaluation ensures that the project creates the expected value once implemented.

4.2.7 Disruption

INFPROs disrupt the local environment, society, and economics. Thus, it is an important factor in deciding whether to pursue a project. While it is possible to mitigate this side effect, such an attempt is considered among the most problematic efforts for stakeholders (Mok et al., 2017; Zeng et al., 2015). For instance, megaprojects can temporarily interrupt the service of existing infrastructures or even air and marine traffic (Mok et al., 2017). Notably, transportation traffic can create costs for the government. It is the case, for example, of Boston's Central Artery project, that estimated road congestions for up to 16 hours a day. Considering penalties for late deliveries, wasted fuel, accident rate, and similar, there was an estimated cost of $500 million (Greiman, 2013). This concept is essential when calculating costs and using tools as CBA.

Megaprojects intrinsically create displacement because of their spatial size. Displacement is not only physical in terms of natural assets (soil, water streams, animals in the area, and natural habitats) but also social. Displacement is both primary – spatially and temporally immediate, like noise and air pollution – and secondary (Cvijović et al., 2021; Gellert & Lynch, 2003). Secondary displacement includes the long-term change of the rural-urban status of the area. Moreover, INFPROs lead to a displacement of biodiversity and ecosystems, changes in the soil, flooding, erosion, landslide, and deforestation (Cvijović et al., 2021; Gellert & Lynch,

2003). Another significant secondary-type displacement is related to the many workers who find themselves without a job in an area with a lot of labor supply and low demand when the project ends. Therefore, the labor market in the area is negatively disrupted if no measures are implemented (Gellert & Lynch, 2003).

In considering whether to undertake the specific project, the portfolio decision-makers should consider whether technology or alternatives can be used to minimize displacement and disruption (Gellert & Lynch, 2003).

An example of disruption is the program of the Chinese government to create a cleaner and less crowded capital city. Xiong'an, a city 130 km from the country's leadership, has been designated as the perfect city for such a destination, with several construction projects aimed to create several jobs and land preparation for the move of hundreds of state-owned enterprises. The government announced the plan in 2017, years after the beginning of construction. Several people decided not to move, leaving the city with only a fraction of the expected people. However, property prices and rent skyrocketed, leaving workers with a shrunk disposable income. Moreover, the space preparation for the state-owned enterprises saw companies forced to close or relocate with their employees. Therefore, the program caused both social and economic disruption (Yu, 2021).

4.2.8 Choosing the Right Time

While the right project(s) goes through a selection and some filters presented above, it is necessary to find the right time to start the project. While this does not prevent an INFPRO from remaining in the pipeline, choosing the right time will prevent the new infrastructure from experiencing additional issues. Moreover, there might be a lack of funding, moving the attention to other less capital-intensive projects.

In situations of lack of funding, realizing benefits in the short term is crucial – e.g., when recovering from a pandemic, maintenance projects can provide high value as they restore the full benefits at a minimum effort (Katseff et al., 2020). An application in case of poor availability of capital is the maintenance of the US roads, as 15% of them are in an "unacceptable" condition (Dobbs et al., 2013). Therefore, maintenance would deliver significant benefits. Moreover, in such situations, selecting cost-reducing projects is recommended, along with digital investments, that improve benefits and reduce the cost of ownership. The foci should be on improving user

experience (UX), making operations more efficient, and reducing service delivery costs (Katseff et al., 2020).

Selecting the right time passes through the technological dilemma presented in the previous subsections. Megaprojects can be designed to extensively use particular technology but then start the building when a new technology has come out (Chang et al., 2013). While considering whether it is the right time to select a project, it is important to gauge what technologies can be used and whether improved versions of such technologies are on the horizon. Experts can offer consulting services and assess whether it is the right time to exploit the technology life cycle model – that follows the S-shaped curve – and the technology adoption model to make a decision (Ayres, 1988; Bohlen & Beal, 1957).

One of the main risks in megaprojects that affect project timing is the supply chain. These projects usually have a global supply chain that generally carries more chances of problems. Partners are not transparent in sharing their intents, and they are not aligned in terms of goals, processes, culture, and structure. Therefore, it is hard to obtain the requested benefits, and problems propagate(Cavusgil & Deligonul, 2012; Kardes et al., 2013). That is relevant in terms of timing because some materials or products might be in shortage in a specific period. Therefore, starting a project might be risky as the needed parts are missing. The shortage of semiconductors and chips is an example of supply chain issues leading to project delay. The workforce can also experience personnel shortages. Furthermore, Steen et al. (2017) highlight that different players in the supply chain might not have the same priorities and agendas regarding the project problems. This situation can create project issues if the timing is incorrect (Söderlund et al., 2017).

4.3 Reaching Out to Stakeholders

While the general idea of the infrastructure is already present when a project enters the portfolio, the solution can change and must be shaped. The targeted benefits remain the same, but it is important to involve stakeholders to adjust the idea and make the project viable. This allows for more flexibility than changing the project after its initiation (Kardes et al., 2013). The section that describes the approaches to megaproject decision-making has already emphasized the importance of collaborative decision-making. However, in public infrastructure development, stakeholders are often the infrastructure user – for instance, companies in the area and citizens. Therefore, it is important to consider their views and collaboratively craft the project. That is not

to say that the stakeholders must initiate the project instead of the government, but the government should involve them. This concept and the reason why it is important are presented in this section.

4.3.1 Defining Stakeholders

For the purposes of this paper, stakeholders are defined as "individuals, groups, or organizations that may affect, be affected by, or perceive themselves to be affected by a decision, activity, or outcome of a portfolio, program, or project. Stakeholders also directly or indirectly influence a project, its performance, or outcome in either a positive or negative way" (Project Management Institute, 2021). Stakeholders are one of the reasons why megaprojects are often reshaped in an iterative and non-linear way during the front-end phase (Miller & Hobbs, 2005). Given the lower costs of shaping the project during early phases, identifying and involving stakeholders as soon as possible is crucial (Miller & Hobbs, 2005; Miller & Lessard, 2000).

The process of identification, prioritization, and management of stakeholders in INFPROs is quite complex given the dynamic importance and interests of stakeholders, but it is necessary (Olander & Landin, 2005; Zamojska & Próchniak, 2017). To that end, considering stakeholder networks becomes crucial even if it adds to the required effort (Mok et al., 2015). Given the definition of stakeholder, Flyvbjerg (2012) adds that mass media are important stakeholders as they are the fourth power of governments. Considering media among stakeholders shows how the influence on other stakeholders is crucial and must be considered.

Table 2 (below) presents two lists of megaproject stakeholders and three different categorizations.

Authors	**Type**	**Categories**
Oliomogbe and Smith (2013)	Non-comprehensive list of stakeholders	Companies, public organizations, authorities, political decision-makers bodies, landowners, customers, community, subcontractors and suppliers, various levels of governments, scientific and technical experts, media, industrial interests and trades in their reputation, and the public interested in environmental and social impacts.

Authors	Type	Categories
Turner and Zolin (2012)	Common megaprojects stakeholders and their interest	The owner interested in long-term value; the sponsor interested in delivering value for the owner with a viable asset that generates value; consumers interested in the value extracted from the use of the product; the infrastructure operator interested in long-term value and low operating costs with early availability, reliability, and maintainability; the project manager and team interested in achieving the triple constraints and learning and future career from the project; the senior supplier interested in making money from their work that helped deliver the project as expected and on cost and time, reducing risks and increasing its own chance of future project; other suppliers interested in being paid promptly and in their reputation; and the public interested in environmental and social impacts
Oliomogbe and Smith (2013)	Stakeholder categorization	Short-term and long-term concerns
Zeng et al. (2015)	Stakeholder categorization	Direct-internal-contractual and indirect-external-public
De Schepper et al. (2014)	Stakeholder categorization	Normative, derivative, and non-stakeholders

Table 2 - Megaproject stakeholder lists and categorizations

Nevertheless, the government does not strive to categorize stakeholders but instead focuses on identifying those who can influence the project. Stakeholders' salience can be dynamically assessed throughout the project by considering their power, legitimacy, and urgency (De Schepper et al., 2014). It is possible to plot stakeholders in a power-urgency matrix. The

result of the assessment is a categorization of stakeholders into a group with similar influence on the project: low influence and uncertainty in the environment (discretionary stakeholders), potential influence but uncertainty in the environment (latent stakeholders), and direct influence on the project and its environment (definitive stakeholder). SM should respectively inform, involve, and collaborate with them (De Schepper et al., 2014). See De Schepper et al. (2014) for the categorization matrix.

4.3.2 Engaging Stakeholders to Create Value

Stakeholder identification and analysis are not only relevant in terms of stakeholder management. In fact, scholars have found that when managers are externally-oriented and create cooperative relationships, INFPROs are more likely to achieve success (Verweij, 2015). Given the centrality of the public initiator and the presence of many external contractors, the traditional unilateral stakeholder management (SM) might not be effective (De Schepper et al., 2014).

Value creation is becoming less and less intended as value creation for another party, but rather enabling the value receivers to create their own value, focusing less on the infrastructure and more on the relationship. In a sense, the project becomes a service. The perceived value depends on emotional, cognitive, and behavioral experience. Therefore, stakeholders need to be engaged and invited to participate in value co-creation at early phases with a collaborative approach (Chang et al., 2013; De Schepper et al., 2014; Liu et al., 2018; McAdam et al., 2010; Oliomogbe & Smith, 2013; Rothengatter, 2008; Sturup, 2009; Verweij, 2015; Zeng et al., 2015). Such an idea is not limited to the INFPRO implementation but also in the ideation phase and even before the project charter. Stakeholder value must be identified throughout the whole INFPRO life cycle and during its operations (Oliomogbe & Smith, 2013). Thus, decision-makers must identify and analyze stakeholders as soon as possible to involve them in the decision-making processes.

INFPROs require the interest and involvement of stakeholders – including the general public and other governments or public organizations – also to fine-tune plans and regulation (El-Gohary et al., 2006; Hueskes et al., 2017; Mok et al., 2017; Vuorinen & Martinsuo, 2019; Zamojska & Próchniak, 2017). Stakeholder concerns are significant and should not be overlooked (Olander & Landin, 2005). In fact, scope changes – including those that originated in the public concerns – are common in megaprojects and lead to cost overruns (Priemus, 2010). The earlier those concerns are addressed, the less costly are potential modifications.

Involving stakeholders also has additional benefits. If the sought value is public and communicated well, the chances of protests are reduced as most of them generate because of the feeling of a lack of value or personal benefits of the promoters (Liu et al., 2018). In fact, acceptance might heavily depend on social skills and the institutionalization of the infrastructure (van den Ende & van Marrewijk, 2019). Therefore, without the involvement of the general public – which is an important stakeholder, it is challenging to communicate the value without a confrontation correctly. When ideas are shared, the stakeholder's point of view becomes more evident, and communicating value becomes less complicated.

Involving the general public and other stakeholders is also crucial from the sustainability standpoint. Indeed, it enhances the social dimension of sustainability (Hueskes et al., 2017; Moehler et al., 2018). Arnstein (1969) stated that citizen participation is "the redistribution of power that enables the have-not citizens […] to be included in the future" (Li et al., 2012). Mok et al. (2015) highlight that involvement promotes fairness and equity, while van den Ende and van Marrewijk (2019) argue that project actors gain legitimacy when involving the public.

Li et al. (2012) state that stakeholders, including the public, can even stop INFPROs if they have concerns. Given the high number of different stakeholders, it is likely that there will be different concerns, even mutually exclusive, increasing the chances of protests. In fact, often, stakeholders do not consider the community interest, but they fight for the problems of a subgroup. For instance, they do not consider the long-term environmental and social benefits while protesting for a temporary inconvenience. Thus, early involvement can also reduce such concerns and eventually lower costs (Osei-Kyei & Chan, 2015; Vuorinen & Martinsuo, 2019).

Involving the general public in consultations as part of stakeholder involvement can also create issues. Sturup (2009) highlights how consultations are usually perceived as a way to have more responsibility for the actions and beliefs. Citizens do so by relying on their own judgment, and it is difficult to reach an agreement about projects. Consequently, public consultation might focus on whether to do the project or not rather than the project implementation, where sovereignty – which is the opposite of governmentality where the power is given to the individuals – should dominate (Sturup, 2009). At the same time, concerns should be collected and considered.

Early stakeholder engagement can include processes (and the related outputs) such as stakeholder training, participation encouragement, resolving differences, input recording, input

classification and analysis, solution identification, and design coordination (El-Gohary et al., 2006).

4.3.3 Dealing with Negatively Impacted Locals

The construction site is significant as the people living there are unique. Locals are affected by INFPROs, and even their identity might be affected (Sturup, 2009). It can be the case that the infrastructure design needs to use private property, and the government has to buy the land to build ultimately, which creates problems (Priemus, 2010). It is hard to convince owners, and it represents an obstacle that can even lead to project cancelation. De Schepper et al. (2014) highlight how stakeholders do have not only a specific power but also an urgency – meaning time-sensitivity and criticality of their claim. The higher the degree of urgency, the more likely it is to influence the focal organization. In the case of locals, urgency is high if they need to be displaced for the INFPRO to happen. If the INFPRO encompasses the need for land purchase, it is appropriate to have a strategy, and the gap should be closed through negotiation and balance between public and private interests (Priemus, 2010).

A prime example comes from the construction of a new terminal of the Mexico City airport. In fact, despite the technical feasibility, the locals received a notice that informed them only a few hours before the project became public. Such behavior led to protests of the *elijatarios* – the local farmers – and eventually, the protests from the whole public as the just above 4,000 farmers were able to gain public opinion. Moreover, during the negotiation, the government did not offer the owners enough money to find a new place and cover their income. Irreparably, that triggered protests, even violent ones, and a much higher offer at a later stage was not considered enough to have them accept and continue the project (Flores Dewey & Davis, 2013). In fact, offering a high sum of money might not be enough even if done initially. Instead, engaging locals from the early phases improves the relationship and might facilitate the negotiation (Sturup, 2009).

Talks with locals should start when the project is still in the feasibility stage and focus on future negotiations. Moreover, the decision-making process should be legitimate and just (Flores Dewey & Davis, 2013). While technical feasibility and the value of the INFPRO are essential, they are not enough to convince the locals to renounce their homes.

There are a few examples of collaboration with indigenous that led to alternative solutions, as they took over for the use of the resources in an area. It is not uncommon to see

natives work with governments on small projects that allow for sustainable use of the resources, with a long-term view. However, the joint projects have social and environmental negative impacts, even if they are consistent with sustainable development (Charest, 1995).

4.3.4 Complaints and Protests

As aforementioned, INFPROs are a source of concerns, complaints, protests, and movements. That is because stakeholders protect their interests or believe the government is not guaranteeing public value. This subsection addresses such episodes, analyzes causes, and suggests strategies.

Different stakeholders perceive the value differently, and therefore apply different strategies to respond, including communicating, complaining and resolving disputes, setting rules and supervising the project, and using decision-making authority (Vuorinen & Martinsuo, 2019). Cvijović et al. (2021) analyzed the case of a hydro-power plant in Serbia and identified four similar strategies: communication, partnership and capacity building, complaints and legal action, and direct action. Therefore, it is crucial to involve them as soon as possible and manage them later.

Every megaproject announcement will cause complaints and protests by different types of stakeholders. Such episodes must not be overlooked as stakeholders cause cost escalation, delays, or even failure (Liu et al., 2018; Mok et al., 2017; van den Ende & van Marrewijk, 2019). Cvijović et al. (2021) found that adverse environmental effects led the protesters to intensify their strategies. In the second part of the last century, we have experienced an increase in movements against INFPROs. These are both legal and political conflicts. These movements are born as responses to disruptive changes that can either bring benefits or pose new threats to a population segment (McAdam et al., 2010).

There are several stories of INFPROs in which public concerns were ignored, and the project was either delayed or canceled. For instance, the Lund railroad project in Sweden was delayed seven years (Olander & Landin, 2005). Another example is the East Line Subway in Amsterdam, whose design implied the evacuation and demolition of a historical market. Protests arose and led to a referendum to implement a different solution that prescribed an above-surface design. The second option won, but the referendum's output was canceled due to a lack of the minimum number of votes. Eventually, the project continued, but the cost was tripled. On top of all this, the project experienced mishaps (van den Ende & van Marrewijk, 2019). A third example

is the case of a hydro-power plant in Thailand. The case showed no participatory mechanism despite the high public expense and the resulting impact on people's lives and the environment. The government only released a few and contradictory pieces of information. Politicians tried to fast-track the megaproject without proper investigation of social, economic, and environmental impacts for their own sake, supporting the project based on a populistic argument. Information focused more on benefits than a proper CBA. The lack of a methodical analysis has been overridden by setting the projects as a national priority, on the wave of popularism, and with the promise to tackle poverty and improve the area. The project has been terminated because of the administration change, but some parts would have probably continued without a valid reason (Molle & Floch, 2008).

Rothengatter (2008) argues that affected residents and landowners (see section above), green organizations, and radical groups are the main stakeholders when it comes to project opposition. Transportation INFPROs – such as highways – are more likely to raise public opposition than other INFPROs like hospitals (El-Gohary et al., 2006). Usually, host country-specific factors are not relevant, while project-specific ones are often the reason for conflicts (McAdam et al., 2010). McAdam et al. (2010) found that they need to use local resources or community resources for movements to be effective, such as community involvement immediately outside the site and political factors. Concerned citizens will also rely on media to be heard and affect change (Flyvbjerg, 2012).

Stakeholder influence is usually intense when they reside within spatial proximity to the project sites. In such a case, the concept of Not In My Back Yard (NIMBY) triggers protests generated within the locals (Liu et al., 2018; McAdam et al., 2010; Mok et al., 2015). Such phenomenon has become more frequent in the past years (McAdam et al., 2010). Protesters might feel threatened because of the risk of fire, air pollution, or other concerns that might also have a character of racism or similar because of the nationality, lifestyle, behaviors, and personal qualities of construction workers – both locals and migrants. As a matter of fact, megaprojects are also disruptive in people's movement as they call for many workers, including migrants (Gellert & Lynch, 2003; Zeng et al., 2015). Liu et al. (2018) highlighted how the construction workers' experience might be a source of complaints, and Gellert and Lynch (2003) extend the concept by mentioning racism.

Locals might believe their future is at risk, but still considering only the very short-term (Liu et al., 2018). Given the NIMBY concept, the public can have a different standpoint than the locals, resulting in disputes (Liu et al., 2018). However, in some cases, the general public can support the locals' cause. A clear example is the canceled project to create a second Mexico City Airport terminal needed to expand the saturated main airport. In that case, the new airport site required the purchase of land of a group of farmers, the *ejidos*, that refused despite the negotiation. Human rights movements and environmentalists, along with the public opinion, sided with them, claiming technical infeasibility to defend the farmers. Eventually, the project was canceled despite its need (Flores Dewey & Davis, 2013).

Engaging stakeholders requires attention as any meeting can be an occasion to invoke disorders and create conflicts, especially in individualistic societies (Li et al., 2012; McAdam et al., 2010). When individuals with shared interests have an opportunity, they connect and group to start conflicts or even public protests to improve their disadvantaged position (Liu et al., 2018; McAdam et al., 2010). To address such a problem, McAdam et al. (2010) analyzed 11 projects from four different continents and found that the involvement must be proactive and thorough. At the same time, conflicting interests should lead to discussing and negotiating to reconcile the needs between stakeholders, even if that might lead to a sub-optimal choice (Li et al., 2012; Mok et al., 2015; Olander & Landin, 2005; Oliomogbe & Smith, 2013). Therefore, the government should mediate to find an optimal solution that includes stakeholder concerns and seeks the optimal sustainable value (Liu et al., 2018). That is possible if the government effectively communicates the project's economic, social, and environmental impacts (Li et al., 2012). George et al. (2000) argue that stakeholder management should aim to collect the issues presented by stakeholders and make project implementation issue-driven rather than stakeholder driver (Mok et al., 2015).

Nevertheless, protesters should be guaranteed the right of self-determination, as protests can sometimes be positive as long as they do not evolve into violent ones (Liu et al., 2018). A threat is that such protests induce repression by social control agents (McAdam et al., 2010). Therefore, managing them is not enough, and active stakeholder engagement is needed to increase the chances of success. They also argue that it is vital to make stakeholders feel understood by other parties to avoid overreactions.

Overall, employing decide-announce-defend techniques - that rely on technocrats – proved unsuccessful (McAdam et al., 2010). Early stakeholder engagement and openness to discussion and evaluation of alternatives must be paramount in any megaprojects to manage complaints and protests. The Operational Level chapter expands on effective ways to engage stakeholders and successfully complete the INFPRO.

4.3.5 Formalizing Stakeholder Management

From the previous subsection, it is clear that communication and stakeholder management cannot be improvised, but there is a need for formal processes and, in general, a stakeholder strategy and the resulting tactics (El-Gohary et al., 2006; Mok et al., 2015). Therefore, Stakeholder Management should be integrated at a program or portfolio level, including creating its own administration (El-Gohary et al., 2006; South et al., 2018). The PMO will internalize this function or coordinate contractors in stakeholder management processes. That is essential as a PMO can make stakeholders from different phases interact (South et al., 2018).

The need for Stakeholder Management also comes from the observation that it can enhance the social dimension performance of the INFPRO as it leads to an analysis of the social consequences, processes, and changes (Moehler et al., 2018; Zamojska & Próchniak, 2017). In order to do so, some argue that there is a need for a shift from Stakeholder Management to Management for Stakeholders (Moehler et al., 2018). The shift is required as, despite the disruptive impact on INFPROs, there is still a gap in effective stakeholder management (Zamojska & Próchniak, 2017).

Stakeholder management should include communication in all phases of the INFPRO, including the close-out phase (Eskerod & Ang, 2017). To that end, value language can engage stakeholders until operations (Eskerod & Ang, 2017).

4.4 The Procurement Method

The government must choose who will care for the project life cycle and the following infrastructure operations at the portfolio or project levels. To that end, decision-makers must select a procurement method that will fit according to different factors. This section presents the different procurement methods and then discusses the reasons for choosing or not the involvement of the private sectors, along with the form of involvement.

4.4.1 The Different Procurement Methods

There are three main delivery methods for INFPROs: direct public provision, contracting-out or traditional public procurement (TPPs), and public-private partnership (PPPs). The former sees the public sector involved in the whole infrastructure life cycle as the leading player, purchasing directly from the private sector. TPPs see the government outsource construction and operations to two different contractors as the product and the service are not bundled. Instead, PPPs assume that different companies as a whole – the private consortium – participate, bringing their expertise in the creation and operation of the infrastructure as the two functions are bundled (Hoppe et al., 2013). Different forms of PPPs depend on ownership sharing (see Table 2 in Kwak et al. (2009) and Table 1 in Siemiatycki (2010) for a comparison of the primary PPP forms). The following subsection expands on each of the procurement methods.

4.4.2 Choosing the Procurement Method

There are criteria to choose a suitable procurement method. For instance, Vining and Boardman (2008) support that a choice that relies on minimizing costs. The cost evaluation should also include government transaction costs and other indirect costs that do not appear in the budget. Moreover, any payment between the public and private in social CBAs should be counted as zero because they are costs for one and benefits for the other, thus, they are transfers. Only production costs should be considered when it comes to public procurement, but they are high due to inefficiencies. For TPPs and PPPs, inefficiencies decrease, but transaction costs increase. However, in TPPs and PPPs, some externalities are internalized. PPPs' transaction costs can rise because of conflicting goals between the private and public sectors. (De Schepper et al., 2015).

Other criteria are based on the idea that PPPs are essentially bundles. Efficient bundles verify three main characteristics: avoiding high bidding prices, avoiding hold-up, and the presence of positive externalities that dominate moral hazard (Teo & Bridge, 2017).

When deciding on the procurement method, the government assesses whether to make or buy one of the activities. To that end, competition is desired as it increases the chances of fair prices and better quality. However, there is a risk of pre-contract market failure risk. Governments can minimize it if they filter out those activities that cannot be divided and reduce the number of bidders (Teo & Bridge, 2017). This way, governments can decide whether to carry out the project and operations themselves or rely on contractors or a contractor consortium. If

unbreakable activities prevent all the companies from bidding, PPPs might not be a good solution, and such activities should be removed from the bundle. Instead, PPPs might be suitable if the activities are large but can be broken down into sub-projects that the government or the contractor can divide. Government can also exclude activities that can result in a hold-up. All the remaining activities after the first two filters can be considered for bundling if they have the potential to generate economies of scope and positive externalities that outweigh negative externalities associated with moral hazard. Elements that increase positive externalities are the importance of the outsourced design activities and operations, and maintenance activities and the complexity of the activities. The rationale for identifying the right bundle a priori is to analyze the activities in the INFPRO identifying activities at the highest level of market specialization; then, the government chooses whether to make or buy based on the hold-up problem, the internal transaction costs associated with organizational heterogeneity, and capabilities associated with production heterogeneity. This leads to a bundling analysis and the decision of whether to form a PPP or not (Teo & Bridge, 2017).

In choosing the procurement method, sustainability considerations should play a significant role as the chosen method will affect the realization of sustainability goals (Hueskes et al., 2017).

If a PPP form is chosen, one of the specific methods must be chosen. To that end, there are short-term and long-term concerns that determine the type of PPP to select. Short-term concerns include: unavailability of funds – even if private financing does not appear to decrease the public debt; impact on different governmental levels; expected level of innovation, level of transparency and public consultation; likelihood of ending on time and budget and delivering the expected benefits; and allocation of risks. On the other hand, long-term concerns encompass: possible future limitations created by a PPP model; delivery of VfM; and potential conflicts between partners that threaten project success. The short-term concerns aim to increase social value in the short run because of political interests (Siemiatycki, 2010).

Overall, if there are no strong incentives for choosing either public procurement or TPPs, PPPs are recommended. In fact, while it is important to evaluate case by case, Iossa and Martimort (2015) found that PPPs – which entails private ownership (at the end, assets become private) and bundling – strictly dominate TPPs – private ownership and unbundling – when the private consortium have incentives to consider innovativeness in building to minimize the future

operating costs and, ultimately, maximize its profits. Transferring design, construction, and operating risks to the contractor provides incentives to keep project costs down and efficiently provide the service.

When choosing the procurement method, decision-makers must be aware of the pros and cons of the selected method. The PMO must address possible threats to procurement success whenever possible through training, standards, and advisory through databases (Kwak et al., 2009; Siemiatycki, 2010).

4.4.3 The Need for Consistency

Whether the choice of the procurement method should be made at the project or portfolio level depends on the personal judgment of the decision-makers. There are factors in favor of both views, but most scholars support at least the choice of a predefined procurement method that can be modified if the bidding process results are unsatisfactory.

Liu et al. (2016) found that when private companies are confident that PPP will be the procurement method, they are more likely to bid. That is the case because bidders seek contracts, and future opportunities might entice them to submit their tender again for another project, even using part of the previous design. Therefore, the authors recommend a portfolio-level decision.

Instead, Teo and Bridge (2017) state that the government should indicate that the PPP is unnecessary if the bidding process does not produce satisfactory results. That way, the government can maximize value-for-money (VfM). Therefore, the authors leave the selection open, even if public procurement is just an alternative to the predefined method.

4.4.4 Public Procurement and Traditional Procurement Method

Public procurement sees the public sector as the leading project player, directly purchasing private companies' goods, services, and workforce (European Commission, 2013). In general, public procurement is not the most used procurement method anymore as trends highlight a tendency to overestimate benefits and underestimate costs. However, the most concerning aspect is the lack of incentives to run ex-post evaluations (Rothengatter, 2008).

In the traditional procurement method (TPP), instead, the government does not carry out the project using contractors but selects contractors to complete the project. One of the main differences with public-private partnerships (see next subsection) is that contractors do not bid as consortia, but the government selects them separately. Moreover, the government decides the design upon consulting. Usually, there is a contractor for the construction and an operator.

Bruzelius et al. (2002) identified several problems of TPPs: lack of feasibility phase due to overcommitment and political sublime; forgotten benefits at early stages in favor of technical feasibility; unconsidered external effects until a later stage; negatively affected stakeholders are not involved until a later stage; absence of a risk analysis; and unrecognized institutional, organization, and accountability issues during project preparation. Additionally, TPPs do not involve the general public and mostly focus on technical solutions rather than sustainability and safety performance. Roles and how objectives are met – along with reward and penalization systems – are not defined, with the public sector in control of all the aspects. Most importantly, performances are poor because of a lack of expertise (Bruzelius et al., 2002).

4.4.5 Public-Private Partnerships

Public-private partnerships (PPPs or P3s) are cooperative institutional arrangements between public and private and, at the same time, a set of governance tools (Hodge & Greve, 2009). The responsibility for delivering INFPROs in PPPs is shared by both the public and private sectors (Shen et al., 2006). The public sector no longer plays the project management role but acts as an auditor, customer, and partner (Shen et al., 2006). In this procurement method, contractors form alliances to create a contractor consortium and assume control over all phases, including the design and subsequent infrastructure operations. There are several types of PPPs depending on the public and private sectors' responsibilities share.

PPPs are not new. In fact, partnerships between the two sectors already existed in the 18th century. Despite existing for a long time, PPPs only became popular in Europe and China in the 1990s, even if they had already appeared in China in the 1980s (Cheng et al., 2016; Chou & Pramudawardhani, 2015). What emerged in the last decades is the private financing and the complex contracting form (Hodge & Greve, 2007, 2009; Siemiatycki, 2010). PPPs have been criticized as some scholars sustain that they are just a "language game" to avoid the words *privatization* and *contracting out* (Hodge & Greve, 2007, 2009). Notwithstanding, such a theory cannot be supported because the public sector is still the ultimate responsible for the results and still has an active role in the whole INFPRO. Additionally, there are many contractors and not just one (Grimsey & Lewis, 2005).

PPPs are valuable instruments to close the infrastructure gap as collaborative work improves innovation and efficiency (Shen et al., 2006; South et al., 2018). Indeed, PPPs are being used to create global INFPROs (Teo & Bridge, 2017). Figures reporting the utilization of

PPPs clearly show that it became the most used INFPROs procurement method. Between 1985 and 2004, there have been 2096 INFPROs that used PPPs (AECOM Consult, 2005). Estimates of the use in China touched 7,000 projects, as of 2014, with increased demand in the 21st century (Cheng et al., 2016). In the European Union (EU) alone, there have been 1,400 PPP INFPROs between 1990 and 2009, that account for €260 billion (Chou & Pramudawardhani, 2015). The United Kingdom (UK) is one of the countries that used PPPs the most and successfully. Its success can be attributed mainly to the excellent communication about risk allocation between the parties (Chou & Pramudawardhani, 2015; Siemiatycki, 2010).

PPPs allow the government – the public sector – to employ a contractor consortium to create infrastructure. It is a crucial procurement method because the government often does not have the needed skills and might struggle to coordinate different contractors. Moreover, the private sector is often more efficient, which produces economic advantages, and both data and the intellectual property of the private sector are used more productively (Tang et al., 2010). The private sector's expectations are rather pessimistic because companies have to take risks. That is a positive trait because of the tendency to be overoptimistic. Moreover, short- and medium-run results dominate the benefit calculation (Rothengatter, 2008). In a way, PPPs can be seen as a tool to "buy" INFPROs off-the-shelf with quicker lead time and better relationships with the private sector (Hodge & Greve, 2007). Additionally, PPPs allow for "competitive dialogue" that enhances the interaction with bidders (Hueskes et al., 2017).

However, the public sector does not become a mere spectator of the project, as PPP is only a partnership, and governments remain accountable for the final product. According to Kwak et al. (2009), the role of the government is to create a favorable investment environment, to establish adequate legal/regulatory frameworks, to establish a coordinating and supportive authority, to select a suitable concessionaire (if any), and to be actively involved in project life-cycle phases.

Employing a PPP procurement method provides several benefits. *Table 3* below summarizes some of them as found in the academic literature. In general, PPPs are more beneficial when operational and maintenance costs are diminished with an increase in the quality of the infrastructure. It is even more effective when the quality creates higher demand – which is stable to forecast – and opens to provide a higher quality service (Iossa & Martimort, 2015).

Author(s)	PPP Benefits
Tang et al. (2010)	Better relationship between public and private sectors, better risk management, clearer government policies, revealed critical success factors (CSFs), improved maturation of contract, and more appropriate financial analysis.
Kwak et al. (2009)	Value for money (VfM), fewer costs and shorter times, less up-front investments and reduced cost of public sector administration, facilitated innovation, transferred risk, and promotion of the local economy and employment
Siemiatycki (2010)	PPPs enable raising money quickly, absorb benefits overestimation, and enhance innovativeness without influencing the plan of the public sector to enhance public value
Karpenko and Shyshova (2015)	PPPs are effective ways to finance sustainability projects, especially when financial resources are lacking or there is an insufficient revenue base of local budgets
Iossa and Martimort (2015)	PPPs can also increase welfare when the quality of service is measurable, the consortium can lower or diversify risk, and the government only contributes with small investments

Table 3 - Benefits of PPPs

Nonetheless, PPPs are not utopic procurement methods as they entail some disadvantages. Tang et al. (2010) mention that the risk of political obstacles and PPPs are not always well understood. Some of the main concerns in PPPs are risks, relationships, and financing (Tang et al., 2010). El-Gohary et al. (2006) argue that public opposition is one of the leading causes of PPPs failure, especially in the US. Additional reasons include the public's unawareness about such procurement method, lack of education about PPPs, and denied access to information. Even when the public is familiar with the concept of PPPs, there is a specificity of them that the public cannot grasp (South et al., 2018). However, PPPs still include a high transactional cost, lengthy procurement processes, lack of appropriate skills, unattractive financial market, incomplete risk transfer, and higher end-user charges (Osei-Kyei & Chan, 2015). Moreover, PPPs have also been criticized for their potential to undermine the ability of

the public sector to plan for the public interest (Siemiatycki, 2010). Differences of views about contracts and gaps in philosophical ideas and expectations between the public and private sectors are sources of conflicts and even PPP termination (Kwak et al., 2009; Tang et al., 2010). Additionally, protesters and opponents can use the innovativeness of the procurement method as an argument in their favor (De Schepper et al., 2014).

There are additional points against PPPs. Kwak et al. (2009) listed: PPPs are not always well understood; there is a lack of knowledge in both sectors to implement PPPs; competition might be limited because of non-negligible bidding costs; they tend to be challenged by the public; there is the risk of higher interest rates for private companies; sharing information can be problematic because of the commercial secrets; and PPPs can result in a monopoly. Moreover, privates tend to underestimate the network and other externalities, even calculating benefits using different schemes than the public sector (Rothengatter, 2008).

Some PPPs have been terminated for a variety of reasons: wide gaps between public and private sector expectations; lack of clear government objectives and commitment; complex decision making; poorly defined sector policies; inadequate legal/regulatory frameworks; poor risk management; low credibility of government policies; inadequate domestic capital markets; lack of mechanisms to attract long-term finance from private sources at affordable rates; poor transparency; and lack of competition (Kwak et al., 2009).

Chou and Pramudawardhani (2015) even state that PPPs can harness the innovativeness capabilities and capital of the private sector. However, most scholars believe the opposite. Instead, PPPs are recognized to be restricting the public sector's future plans. Clauses that allow flexibility for future community needs and the ability to disclose some information to the public should be included in contracts (Siemiatycki, 2010).

Implementing PPPs does not automatically result in the desired benefits. In fact, several critical success factors (CSFs) increase the chances of successful PPPs. CSFs refer to specific "conditions, events, and circumstances that contribute to project results" (Fahri et al., 2015; Ika, 2009). *Table 4* below summarizes several CSFs present in the PPP literature.

Author(s)	Type	Content
Osei-Kyei and Chan (2015)	PPP CSFs list	Appropriate allocation of risks between the public and the private sectors, a robust private consortium, political support, community support, and transparent procurement. Political support of the project and the INFPRO is crucial as it attracts potential investors and strengthens the consortium.
Liu et al. (2016)	PPP CSFs list divided by group	(A) Robustness of business case development (existence of service needs, project economic viability, and robustness of procurement options analysis); (B) quality of project briefs (clarity of project brief and client requirements and availability of PPP guidelines and standardized documentation); (C) public sector capacity (public sector's experience and knowledge, political support, and public sector leadership); (D) governance structures (clarity and responsiveness of governance structures); (E) level of competition in tendering processes (competitiveness of tendering processes); and (F) level of transparency of tending processes (transparency of procurement system).
Kwak et al. (2009)	PPP CSFs list	Inclusion of decision-makers in the project team from the start; measured results to monitor project progress; goal-directed and result-focused PPP; periodic progress monitoring during implementation; independent project team and an independent project leader reporting to a steering committee of top representatives from both the public and private sectors; spread political and economic risks at an early stage; adequate and clear working methods and agreements; allowing the private sector to fulfill its entrepreneurial role; and mutual confidence.
Tang et al. (2010),	PPP CSF	Solid relationships between the public and private sectors are perceived as crucial to providing benefits.

Author(s)	Type	Content
Verweij (2015)	PPP CSF	Collaboration between the public and private sectors is conducive to INFPRO's success.

Table 4 - PPP CSFs

While the public sector needs to acknowledge the CSFs, some incentives entice the private sector to participate in PPPs. In fact, such partnerships allow private companies to maximize their risk-adjusted profits, create subsidiaries to have the bankruptcy option available through the concept of limited liability, use third-party debt financing to limit capital exposure, and quickly sell most or all of their equity to other parties (De Schepper et al., 2015).

P3s are not just the result of interactions of different stakeholders with different institutional ideas but also the product of different phases (South et al., 2018). Hueskes et al. (2017) describe the process of formation of PPPs in four steps:

(1) project identification that includes definition and outputs;
(2) detailed preparation phase with the design of procurement method and PPP, bid criteria, and involvement of stakeholders;
(3) procurement phase that goes from the interaction with bidders to the contract award and contracts; and
(4) the project implementation phase.

Alternatively, South et al. (2018) propose the following four phases: identification, procurement triggered by requests for proposal (RFPs), design/construction, and operation/maintenance.

In the PPP formation process, sustainability can influence each phase. During the project identification phase, the project promoter can set sustainability norms in output specifications and use sustainability instruments. During the detailed preparation phase, the government should involve stakeholders and weight sustainability award criteria. During the procurement phase, must experience competition in quality rather than in price. Finally, during the implementation phase, there must be rewards (Hueskes et al., 2017; Siemiatycki, 2010).

4.4.6 Competence and Efficiency Factors

Two factors that determine the procurement method are efficiency and competence. While these are not the only factors, they are very important and often the only ones considered

for the choice. Competence indicates whether governments have the required skills to manage INFPROs by themselves, purchasing material and individual construction services. Alternatively, the government might be capable of designing the infrastructure through consulting services and then selecting two or more contractors for execution and operations. In the first case, public procurement is an option, while the latter is suitable for TPPs. However, if the government does not have such skills, PPPs might be the best option. However, efficiency is also crucial. While the government might use public procurement or TPPs, the private sector might provide higher efficiency, reducing times and costs while keeping the desired quality or even improving it with innovations. In addition to the basic considerations, scholars highlighted other points when considering the efficiency and competence factors.

If incentives and instruments are used, PPPs might have a higher sustainability impact on the overall infrastructure life cycle. To that end, it is important to consider that the private sector does not have the same interests as the public sector. If the consortium has to design, build, finance, operate, and maintain (DBFOM contract) the infrastructure, they are incentivized to optimize the product and the process, having a long-term view (Hueskes et al., 2017). To that end, it is crucial to gauge whether the public sector has better skills in coordinating different contractors or it is better for contractors to organize themselves. Still, while the economic aspect is always a factor and the environmental dimension can be brought in through payment for negative externalities or bonuses for positive ones, the social dimension is rarely a factor.

Another aspect is the project management responsibilities. In PPPs, the project management functions are partially divided between the two parties (De Schepper et al., 2014). Therefore, both competence and efficiency in such discipline should be assessed for both the government and the potential bidders. At the same time, decision-makers must evaluate whether a collaboration between the two sectors is possible. That is crucial as collaboration is one of the previously mentioned CSFs.

De Schepper et al. (2014) suggest involving stakeholders before creating PPPs because their concerns are already known. Thus, the private and public sectors can share the concerns in a more efficient way. In fact, decision-makers can gauge whether the government has the competencies to address such concerns or the private sector has the specific knowledge.

A final aspect is that PPPs can help share the knowledge in different projects (Aerts et al., 2017). That matters in terms of knowledge sharing across INFPROs. If the private sector has experience with similar projects, there are incentives to choose either TPPs or PPPs.

4.4.7 The Risk Sharing Factor

When considering the procurement method, risks must be taken into account because they are crucial for the INFPRO success. To that end, PPPs are often praised. Indeed, an essential benefit of PPPs is that risk is shared between the two sectors (De Schepper et al., 2014; Osei-Kyei & Chan, 2015; Tang et al., 2010). Risk allocation in PPPs depends on who has the best knowledge and resources to address them. Proper risk allocation is one of the overall factors for success (Kwak et al., 2009).

While risks are shared, there must be a well-defined system for risk-sharing (Osei-Kyei & Chan, 2015). It should be noted that this process takes time and requires prolonged discussions (Aerts et al., 2017). They can be allocated in contracts by type, based on the ability to address them. Political, financial, and legal problems (i.e., environmental risks) should be taken by the government, while operation-related ones by the private sector (Kwak et al., 2009). Rothengatter (2008) adds that force majeure risks should be allocated to the public, and financial risks shared to tackle interest rates.

In conclusion, PPPs offer great tools to share risks between the two sectors but require time and efforts that might not be possible in some cases. Consequently, decision-makers must weigh the benefits and costs of PPPs' risk sharing when selecting the procurement method.

4.4.8 Financing Considerations

A sound financial package is key to INFPRO's success (Kwak et al., 2009). Since different procurement methods open to different financing options, it is crucial to select the right one.

When considering the requirements of the financial package, risks are a decisive factor (Tang et al., 2010). The overall level of risk, the number of risks, the probability, and their impact influence who finances the INFPRO. As a matter of fact, public procurement and TPPs do not allow external funding, leaving the burden of risks to the government and, ultimately, to taxpayers. PPPs, instead, are open to private funding. Therefore, if the decision-makers lean on the first two methods, the choice becomes where taxes must be collected. Instead, in the case of PPPs, there is a world of options that can be customized to the project.

Generally, given the complexity of INFPROs, financial engineering is needed to find the right solution for different interests. Financial structures must reflect the long lifetime of infrastructures (Walter, 2016). While financial arrangements might be very contract-intensive, they can comprise equity, commercial loans, and fixed-income securities (Walter, 2016). Commercial loans are crucial, especially in the first phases of INFPROs, because of their reliability. Not even the global financial crises of 2007-2008 prevented banks from providing financing to viable INFPROs. In fact, the infrastructure equity has performed well over various periods compared to standard equity indexes (Walter, 2016). Usually, megaprojects are seen as separate entities, and 10-30% are funded by equity, while 70-90% by debt as investors are interested (Kwak et al., 2009).

Private funding presents some problems. For instance, there could be a blockage in global infrastructure financing. Walter (2016) suggests that institutional initiatives and policy measures could help catalyze such blockage through reforms in traditional multilateral agencies and new entrants. However, currently, there is no shortage of available funding but rather a lack of financeable infrastructure projects. Currently, banks provide roughly 90-95% of INFPROs' debt any given year. (Walter, 2016). However, it is legitimate to ask whether PPPs create inefficiencies in terms of money borrowing and risk transfer when the cost of borrowing public funds is lower, or the government can inherently manage certain risks better (Teo & Bridge, 2017).

Iossa and Martimort (2015) stated that, contrary to common sense, PPPs do not seem to provide benefits in terms of cost overruns with respect to traditional procurement. The reason why PPPs are employed more than TPPs is because of the other benefits.

The lack of financeable INFPROs is essential as the willingness of private institutions to finance a project is a sign of its ability to provide benefits (Bruzelius et al., 2002).

As INFPROs last for decades, some macroeconomics concepts must be drawn into the discussion. The main ones are the concept of inflation and exchange rates. The former is one of the leading causes of cost overruns in the famous Boston Big Dig. Not only the yearly inflation must be taken into account during the cost calculations, but delays and challenges in the construction lead to a schedule longer than expected, which influences the budget even more because of inflation (Greiman, 2013). Exchange rates can quickly fluctuate because of the long-term agreements (Irimia-Diéguez et al., 2014). For instance, unstable exchange rates were a

cause of cost overruns in the Marmaray Tunnel in Turkey (Kardes et al., 2013). Analyses can help indicate the general trend over the megaproject's duration to better estimate costs. Thus, the financing company must include such considerations in its proposal.

Nonetheless, politicians often choose private financing because it keeps the investment off the state's balance sheet, i.e., off their administration's balance sheet. Scholars agree that it is not ethical and should be avoided (Iossa & Martimort, 2015; Siemiatycki, 2010).

4.4.9 Dealing with Agency Cost

Another aspect to consider when assessing the best procurement method is agency or transaction costs with contractors. While even public procurement purchases services and goods, agency costs are lower than TPPs and PPPs. Transaction costs – the cost of creating and maintaining a partnership – are especially burdensome in PPPs. They include legal, financial, and technical advisory costs for both the private and public (De Schepper et al., 2015).

The ultimate reason why there are agency costs is that there is information asymmetry between the two sectors, and it has often been used to raise prices and profits. In fact, INFPROs are based on asset specificity, enabling opportunistic behavior because small companies commit to investing in assets with limited usefulness. At the same time, the public sector cannot withdraw from the contract because of the high costs. Asset specificity is more common in PPPs than TPPs (De Schepper et al., 2015).

While the frequency of communication between the sectors increases transactional costs, a relationship decreases them because the parties develop trust (De Schepper et al., 2015). Thus, while public procurement reduces the frequency of communication with contractors, TPPs and PPPs can develop trust with bidders, even across different projects, and develop trust, ultimately decreasing transaction costs. To that end, Flammer and Bansal (2017) found that a long-term perspective – which was presented as the primary philosophical approach to INFPROs – helps mitigate agency conflict. In the case of both public procurement and TPPs, relationships with contractors appear to be one-off, while in PPPs, there is a project-long relationship and potentially a portfolio-long one.

While governments can consider integrating vertically with public procurement – and partially TPPs – to avoid most agency costs, they must consider a different type of cost, namely, direct management. Moreover, it is unlikely that the public sector will reach more economies of scale than the private (De Schepper et al., 2015).

Finally, a PMO can play a crucial role in decreasing agency costs and direct management expenses by creating standards, enhancing knowledge management, and creating contract(ing) templates.

4.4.10 Delivering Value for Money (VfM)

Governments choose PPPs because they want to achieve value for money (VfM). There are six main determinants of VfM: (1) risk transfer; (2) the long-term nature of contracts (including whole-of-life cycle costing); (3) the use of an output specification; (4) competition; (5) performance measurement and incentives; and (6) private sector management skills. Therefore, the contract must be given using a competitive environment, with rigorous economic appraisal and risk allocation, and the comparison between publicly and privately financed options analyzed. All of these are pre-conditions but not a guarantee of VFM. (Grimsey & Lewis, 2005). Evaluating VfM help decide what procurement method is the most reliable for the INFPRO, with the caveat that TPPs are usually not included in the assessment.

Ultimately, VfM is achieved when (Grimsey & Lewis, 2005):

$$Cost\ of\ service_{private\ sector} < base\ cost + transferrable\ risks + competitive\ neutrality_{public\ sector}$$

The first aspect is evaluating if PPPs historically deliver VfM. Grimsey and Lewis (2005) summarize some studies finding that savings are between 5% and 40% of the project cost, with different ranges depending on the study. The reasons might be found in the over-conservative decisions and over-engineered designs of the public sector. Moreover, the public sector does not have the same incentives to act in commercially oriented ways. Despite PPPs addressing agency problems, the private sector manages risks increasing efficiency, and resources are allocated more efficiently and effectively (Grimsey & Lewis, 2005). Scholars agree that PPPs create VfM (Hodge & Greve, 2009). Therefore, it is legitimate to evaluate whether, in the specific case, a PPP approach delivers VfM compared to the traditional methods.

VfM can be assessed using a benchmark of costs under public procurement – the Public Sector Comparator (PSC) – and under a PPP scheme (Grimsey & Lewis, 2005). However, the PSC is only one option. In fact, there are different approaches to assessing VfM: the CBA, the PSC-PPP comparison before bids are invited – using a hypothetical "shadow" PPP, the PSC-PPP comparison after the bids, and reliance on competition to achieve VfM (Grimsey & Lewis, 2005). Decision-makers do not need to pick one of the options but can compare the VfM at different stages of the PPP bidding process.

PSC is effective because it forces to evaluate the full costing at an early stage, provides a management tool in terms of risk allocation, output specs, comprehensive costing, tests VFM, encourages benchmarking and evaluation, increases competition and financial rigor and probity principles (Grimsey & Lewis, 2005).

For the purpose of assessing the VfM of a PPP in comparison with the PSC, decision-makers can liken the cost of public procurement against the cash flow to the private sector plus the risks not transferred. Clearly, this process is performed before the actual project, so it is a hypothetical comparison. Another way is to undertake a complete financial analysis of the public options and the real PPP bids. However, the latter requires too great an effort, and there is subjectivity involved in evaluating the economic costs and benefits (Grimsey & Lewis, 2005).

For consistency purposes, the PSC must have the same assumptions of PPPs in terms of timing (start and end dates), funding, procurement costs (ignoring costs of implementing PPPs), output specifications, and performance standards. Risk identification must be included in the PSC, considering only the retained risks for PPPs. At the same time, the PSC method should count that with PPPs, a part of the profits returns to the government because of profit taxes – where they exist (Grimsey & Lewis, 2005).

The raw PSC should consider the usual costs, costs of achieving efficiencies/innovation, the opportunity cost of assets to be used, and any decommission costs at the end of the project. Some socio-economic costs may be excluded if there is no significant difference with the private sector (Grimsey & Lewis, 2005).

While PSC can include subjective judgment, there is no interest in underestimating the cost (Grimsey & Lewis, 2005). The discount rate is one of the main factors to estimate in order to calculate the benchmark. Options for the discount rate include (Grimsey & Lewis, 2005):

- a fixed rate based on the low-risk cost of private capital as opportunity cost,
- a fixed rate based on the cost of risk and optimism bias,
- the rate derived from the capital-asset pricing model (CAPM) will lead the winning bid to use the right discount rate for the specific project.

Therefore, the two overall approaches add risk to a risk-free discount rate or consider risk in the cash flow (Grimsey & Lewis, 2005).

Some scholars argue that PSC is not relevant, and it is an unjustified expense that increases the INFPRO costs if the project is similar to a previous one. While that is sometimes

the case, PSC is beneficial as it assures competition and seeks to obtain the best deal, improving transparency and lowering the risks of problems in the audit (Grimsey & Lewis, 2005).

A crucial problem with the method is that PSC is incomplete as it does not consider some qualitative factors (Grimsey & Lewis, 2005). Moreover, PSC might not be a relevant indicator to calculate the NPV of different PPP bids because of traditional government finance (Teo & Bridge, 2017).

Since the PSC method is not very accurate, it is advisable to have total cost ranges to compare rather than a single number. When there are minor differences between the two, PPPs might still be beneficial for the risk allocation factor (Grimsey & Lewis, 2005).

However, Teo and Bridge (2017) stress that decision-makers can assess VfM using other methods. In fact, the PSC does not account for some untraceable internal and external costs, and benefits are difficult to isolate. The authors propose two indirect methods:

- the multi-attribute utility approach (MAUA) includes clients' and experts' criteria without using the monetary value. It is a powerful method to assess the bids at an early stage, but it does not consider the life cycle value; and
- bundling that includes a negative opportunistic behavior but also the potential to internalize positive externalities.

4.5 Selecting a Contractor Consortium

INFPRO success heavily depends on selecting appropriate concessionaires (Kwak et al., 2009). While the bidding process might appear uncontrollable, some factors can determine whether the contractors or the consortium will likely deliver the project successfully, creating value. In this section, the analysis turns to the differences between individual contractors and a contractor consortium, the preparation and operations of the bidding process, and finally, it identifies selection criteria.

4.5.1 Consortium vs. Individual Contractors

Public procurement and TPPs share the need for the government to select individual contractors, while in PPPs, companies organize into a consortium and present their bids as a whole. There are essential differences between the two methods, and it is important to acknowledge them to manage contractors better.

Different companies are specialized in design, financing, building, among others. Osei-Kyei and Chan (2015) emphasize how it is difficult for a single contractor to run the whole project and the operations of the infrastructure. Therefore, the natural solution is for different private companies to cooperate and create a consortium. In fact, when the decision-makers choose the different contractors, there might be an incompatibility between companies and, in general, less agreement between the parties.

Within consortia, the private sector needs to involve financial institutions early if the PPP scheme provides private funding and maintains a long-term relationship with the financing institution (Kwak et al., 2009). Private financing can incentivize the infrastructure operator when the financer brings its expertise in monitoring and control (Iossa & Martimort, 2015).

4.5.2 Preparing the Bidding Process

The bidding process is within the sphere of influence of the decision-makers. That works for both TPPs and PPPs. A well-crafted bidding process can enhance the chances of a successful collaboration. To that end, decision-makers can prepare the bidding process following the suggestions presented in the next paragraphs.

One of the first problems to be addressed is that the team in charge often lacks the required skills (Liu et al., 2016). To that end, a PMO can help train the decision-makers and provide previous knowledge for higher bidding process effectiveness.

Earlier, it has been mentioned that the megaproject's life cycle starts with the problem analysis (Priemus, 2010) and that within a portfolio context, the next step is a request for projects. However, when selecting contractors, it is crucial to specify what Priemus (2010) considers the second step, namely, compiling a functional program of requirements. Clearly defined requirements can communicate better the expectations to potential bidders that provide a higher-level bid. However, it is even more important for the public initiator must clearly define the goals of the INFPRO as lack of clarity can lead to termination of the PPP relationship (Kwak et al., 2009). Overall, the bidding process should be transparent. This includes winning chances that should be of public access to create room for competition (De Schepper et al., 2015).

Transparency is not directly related to certainty. Priemus (2010) highlights that the approach should not seek certainty but rather uncertainty as it is conducive also to learning and making the best decisions. The whole tendering process brings uncertainty, as the winners get a

high turnover, while the others lose the costs for the bid. Therefore, the bidding process must be carefully crafted (De Schepper et al., 2015).

There is a need for effort from the public side contractor as lowering relationship-specificity will enhance the learning process, which indirectly lowers the investment. Moreover, it has been found that a higher commitment to the potential PPP does not increase the chances of winning the bidding process (De Schepper et al., 2015).

The duration of the tendering process can influence the following relationship between the sectors. In fact, De Schepper et al. (2015) found that, while shorter procurement times do not reduce the relationship-specific investment, they reduce lock-in effects. Therefore, a shorter bidding process is desirable.

An important observation is that PPPs have been criticized because of the inefficiency and ineffectiveness of the tendering process, including lengthy duration, high transactional cost, and lack of competition and transparency. Moreover, bidding and contracting account for 2.5-4% of the project cost. Therefore, it is crucial to design the bidding process properly (Liu et al., 2016).

Because of knowledge transfer – which is enabled through the presence of a PMO, the government can indicate their ideal solution or bid thanks to repeated consultation. Moreover, there can also be a reference design. Such tools increase the quality of the bids and streamline the process (Aerts et al., 2017). With time, it is important to standardize the procurement process and increase the institutional capacity (De Schepper et al., 2015).

4.5.3 The Bidding Process

Once the approach to the tendering process is defined, decision-makers must define the bidding process. To that end, they must recognize the possible options and the pros and cons of each. Once the whole process is well-crafted, it can be made public and encourage bidders to present their designs.

Depending on the jurisdiction, there are three possible schemes for the tendering process (Liu et al., 2016):

- *Direct negotiation.* Companies directly approach the government with innovative ideas and their cost-effectiveness and low transactional cost. However, there is a high risk of lack of transparency and corruption.

- *Competitive negotiation*. There is a pre-qualification phase, followed by an invitation to negotiate and a request for the best and final offer, and ultimately the choice of the preferred tenderer. The number of tenderers reduces as the process progresses with the risk of long negotiation and lack of transparency.
- *Competitive tendering*. It can be open, single-stage, or multi-stage, with an invitation to a binding offer, and the price does not entail any negotiation. Such a scheme reduces costs but also innovativeness. However, the multi-stage option might still include innovativeness, but there are negotiation and tendering costs.

Gordon (1994) studied the awarding method and stated that commodities should be awarded through bidding, while services through negotiation or multi-criteria bidding.

4.5.4 Encouraging Bidders

When many consortia participate in the bidding process, there are higher chances of lower costs and higher innovativeness (Liu et al., 2016; Siemiatycki, 2010). At the same time, when there is high competition on price, companies are encouraged to tender using strategic misrepresentation to win (Flyvbjerg, 2006).

A good bidding process design is ineffectual if there are no bidders. In fact, companies invest money in preparing a bid – which includes a design draft – with the risk of losing. Consequently, there must be incentives to bid. The importance of having an INFPRO portfolio is that, despite the possibility of losing the contract, there is a straightforward project pipeline, and companies can win another one (Liu et al., 2016),

It is interesting how private consortia still submit their bids, incurring a sunk cost when the government does not reciprocate. They do so because of two spill-over effects: reputation and capacity enhancement. Therefore, companies are more likely to commit resources without expecting other sunk cost investments from the public sector if the uncertainty is low, frequency high, and possible spill-over effect high. They would even accept a negative NPV in order to learn, strengthen status, and increase capacity. The public sector should encourage bidding, but without removing barriers to enter the procurement completely. (De Schepper et al., 2015).
A technique is to reimburse bidding costs, even if that requires high additional costs (Vining & Boardman, 2008). In order to keep barriers, the public sector can set design and timing requirements, allocating the risk of not meeting such constraints to the private sector.

4.5.5 Selection Criteria

Not all companies or consortia are suitable to build public infrastructures. Setting selection criteria allows filtering through them in a pre-selection phase. However, the pre-selection criteria must not be set too strict as such an approach might reduce the number of bidders to a level in which innovativeness is hindered (Hueskes et al., 2017).

The first step in the selection is submitting information by the companies about their capabilities and their technical and financial proposal (Liu et al., 2016).
The technical knowledge, experience, and financial standings should be pre-selection factors to assess potential bidders (Hueskes et al., 2017). Moreover, Tang et al. (2010) state that it is essential to consider innovativeness. Gordon (1994) states that selection should base on project drivers (time, flexibility, preconstruction service, design process, and financial constraints), owner drivers (sophistication, current capabilities, risk aversion, restriction on methods, and other external factors), and market drivers (availability of the contractor, state of the market, and package size of the project). The first selection should be made using project drivers, then refined with owner drivers, and ultimately awarded through market drivers. Sustainability criteria for contractor selection should be generally aligned with the output specifications of the contracts to be made (Hueskes et al., 2017). Some preselection criteria divided by type are presented in Kwak et al. (2009), Table 6.

While it is crucial to assess companies, filtering out passes through excluding companies or consortia that proved unreliable in the past. For instance, the presence of sustainability laws breaching episodes can be an exclusion factor (Hueskes et al., 2017).

After a proper pre-selection, companies submit their proposals. Some tender evaluation methods that are currently in use are (Kwak et al., 2009; Zhang, 2004a, 2004b):

- the simple scoring method – scores are assigned to different criteria per each tender offer, and the winner is the bidder whose sum of all the criteria scores is the highest;
- NPV method – the bidder with the lowest Net Present Value (NPV) of tolls and tariffs (or the higher NPV of the project) win the selection;
- multi-attribute analysis (MCA) – similar to the simple scoring method, but each criterion has a weight, and several criteria can be merged in the so-called subpackage;

- Kepner-Tregoe decision analysis technique – MUST and WANT criteria are selected, limiting the analysis of the former to a “yes” or “no”, while the latter are judged with relative importance;
- two-envelope method – bidders first submit their price in an envelope, leaving the government to assess bidders on other criteria, and then envelops are opened to check whether the price is within the allocated budget (unknown to the bidders);
- NPV method plus scoring method – links the NPV method for financials and a scoring method for qualitative evaluations; and
- binary method plus NPV method – first MUST criteria filter out unsuitable tenders, and then the NPV method ranks the remaining bids.

The multi-attribute analysis and the Kepner-Tregoe decision analysis technique may be more suitable for complex PPP projects (Kwak et al., 2009; Zhang, 2004a, 2004b).

4.6 Transparency and Communication Management

An essential factor of INFPRO management is managing communication. The public sector frequently communicates with contractors (see the section below), locals, the general public, businesses, and others to coordinate for a successful project. Effective and proper communication is so important because imperfect communication is a source of protest (Liu et al., 2018). Transparency goes along with communication to create benefits that work for the project success.

As aforementioned, communication must address both the general public and the other stakeholders such as contractors and project personnel. Communication supports the governance structure and makes the collection of ideas possible (Chang et al., 2013). Moreover, the project team is equipped to respond to possible critiques (Liu et al., 2018).

Scholars suggest a communication design that entails using different channels to explain and advertise the project's rationale to external stakeholders (Bruzelius et al., 2002; Verweij, 2015). Additionally, the plan should include contacting stakeholders to make successes public (Sturup, 2009).

Communication must be targeted, and there can be different channels for different target receivers. It is vital to direct most efforts toward those stakeholders that perceive the project outputs to the highest degrees. This approach presents suggestions for the formulation of

sustainability in contracts: indexes can be more easily indicated for environmental and economic outputs, while the social dimension is more easily assessed through the perceived outputs (Zamojska & Próchniak, 2017).

In addition to engaging stakeholders, communication management should aim to keep them informed. As previously mentioned, people require information, and providing it enhances project acceptance (El-Gohary et al., 2006). For instance, El-Gohary et al. (2006) found that hiding information from citizens in PPPs causes public opposition, which may result in failure. In fact, people demand transparency which is conducive to the creation of trust. Both transparency and trust are crucial for stakeholder involvement because the public is skeptical when the public sector tries to involve the community and might decide not to participate if they have reasons to believe the choice has been made beforehand (El-Gohary et al., 2006).

Transparency and openness to criticism are crucial to ensure democracy and keep project players accountable (Bruzelius et al., 2002; Flyvbjerg, 2012). As a matter of fact, Flyvbjerg (2012) analyzed a case in which he was himself involved as he discovered untruthful news about megaprojects in Denmark. Despite being contacted by governmental officials, he disclosed information, and even employees started to leak details. While a case is not representative of all megaprojects, the governments should commit to the highest standards. Consequently, there is no alternative to transparency and openness to critique, even if transparency means revealing inconvenient details.

Another point in favor of transparency is that it supports sustainable development, especially when coupled with ethics. Such an approach is the equivalent of corporate social responsibility (CSR) for INFPROs. When "implementing CSR", INFPROs consider broader expectations of society, mainly when applied throughout the whole project (Zeng et al., 2015). INFPRO's social responsibility includes four responsibilities: economic, legal, ethical, and political (e.g., support employment). The four responsibilities can be plotted into a 3-D graph with the different phases, showing how much each responsibility is needed for the different stakeholders (Zeng et al., 2015).

Transparency should not be confused with openness to accept any change request by the public. In fact, while there is a 2-ways communication channel during the design phase that entails co-design and feedback, communication becomes more one-way during construction (El-Gohary et al., 2006). Having public consultations while the project is in the implementation or

construction phase is considered one of the main problems stakeholders face in INFPROs. Nonetheless, the project personnel should still welcome suggestions and receive feedback (Liu et al., 2018; Mok et al., 2017).

While communicating to the general public, there are two options: either higher expectations or lower them. Hartmann and Hietbrink (2013) studied the phenomenon and concluded that there is no convergence among studies on whether one of the options is better. However, the authors found that the public's experience with the new infrastructure is more relevant than meeting the expectations. Experience is not limited to the use of the new or renewed infrastructure, but it extends to the level of information the general public receives. In fact, people require information, which, in turn, increase project acceptance. The case of the A20 highway road maintenance project in the Netherlands shows us that, despite the inconvenience of having a part of the road blocked for maintenance, informing people well in advance, keeping them informed, and assuring a great user experience will create stakeholder satisfaction.

Examples of effective communication and stakeholder engagement are presented in the Operational Level chapter.

4.7 Managing Contracts and Contractors

Contractors are among the main INFPRO stakeholders. They have a very active role and must be managed carefully. It is important to manage contracts and contractors as the contract type, project scope, and project size play a crucial role in the final satisfaction with the project (Flyvbjerg, 2017; Verweij, 2015).

4.7.1 Contract Type Strategies

The public and private sectors are bound through contracts. Contractors agree to provide defined goods and services in exchange for a price. Decision-makers must decide what must be bundled, how the price is determined, whether to have an overarching approach or rely on the relationship and other factors. Therefore, it is important to have a contract strategy.

A crucial aspect of contract crafting is the pricing factor. When costs are contractible, contracts should be based on profits, else, on revenues. There is a risk factor in the first case, and the contact heavily depends on the transferred risk to the private sector (Iossa & Martimort, 2015). When costs are difficult to estimate, the government should base the contract on revenues, leaving the risks of cost overruns to the private sector, ensuring profits. While this idea might be

difficult to put into practice, the procurement method might help. In fact, in PPPs, risks are shared, and the private sector might be willing to take ownership of some risks. There is also a third case where only costs are predictable while no revenues come from the community. In such cases, cost-plus contracts or fixed payments from the government are recommended (Iossa & Martimort, 2015).

A second consideration regards the bundling of services and phases. Iossa and Martimort (2015) suggest that contracts should bundle construction and infrastructure operations when contractors benefit from positive externalities on the asset management if they use innovation in building techniques, materials, or design. That is the case because the consortium tries to maximize its profit, and it is incentivized to consider long-term performances of the asset. That is especially true when many risks are allocated to the private sector, as the consortium will attempt to internalize those externalities even more by producing a high-quality infrastructure and minimize operating costs. Therefore, it is recommended that contracts include bundling and fixed-price contracts, especially in PPPs (Iossa & Martimort, 2015). Bundling is also advisable when contracts can include operating costs and quality indexes. In such a case, using game theory terminology, "bundling strictly dominates unbundling" (Iossa & Martimort, 2015).

Financing should be bundled with the rest as it is better than public financing. This holds if external financiers know the level of effort of the operator. Bundling financing accelerates the construction and improves the sharing of risks. Therefore, the authors recommend a PPP procurement method. However, PPPs are characterized by higher costs, and bundling can make smaller companies refrain from bidding (Iossa & Martimort, 2015). That is the case because the contract type must be determined before the start of the bidding process.

It is also essential to notice that infrastructures will depreciate, so contractors might need incentives to keep the commitment until the end. The optimal long-term contract entails high-powered incentives toward the end of the contract rather than at the beginning. Iossa and Martimort (2015) found that with ex-post asymmetric information between the parties, there are substantial concerns about the strategic cost overruns. "The optimal menu of incentive contracts that prevents cost overruns is such that the less efficient firm produces under low powered incentives whereas the firm receives incomplete insurance against the realizations of innate cost." (Iossa & Martimort, 2015).

Overall, it is impossible to concentrate everything in a contract. Too strict contracts are dangerous as not all the outcomes can be specified at first, so flexibility is needed (Flyvbjerg, 2017). The impossibility of formulating a comprehensive contract creates room for opportunism, negative externalities, or reductions in quality. As a matter of fact, the private sector wants to maximize the profits and NPV over the infrastructure life cycle coming from a high-risk premium while minimizing the price, or leastways reduce risks in exchange for a small fraction of the profit. The private sector will also track revenue-enhancing or cost-reducing opportunities. Instead, the public sector wants to minimize the social cost of the current administration, deferring others to future legislative periods. Therefore, there are different objective functions, and transaction costs are high. These effects can be minimized by implementing some prescriptions (De Schepper et al., 2015). To that end, De Schepper et al. (2015) recommend:

- establishing a jurisdictional PPP constitution that requires transparency and timely budget reporting to avoid claims of secrecy of the information;
- separating the agency that analyzes the project (e.g., CBAs) from the one deciding the procurement form, the one conducting the bidding process, and the one evaluating the process;
- ensuring that the bidding process is reasonably competitive enough to allow companies' tender offers and proactively searching for bidders until an optimal number is reached;
- being wary that specific asset investment may suffer from frequent changes and will require higher renegotiation costs;
- including fast, low-cost, and standardized arbitration procedures to reduce lawsuit cost; avoid equity-protecting companies that create subsidiaries to set a cap for they want to risk;
- prohibiting the private party from selling the contract too early as the life cycle is designed to have them thinking about the operating phase; and
- having a direct conduit to debt holders – as trustees will delay the procedure – and negotiating.

The alliance model is an enabler for sustainability as it enhances collaboration between contractors, customers, and owners, promoting risks and benefits sharing. It also increases innovation to reach sustainability goals. Planning occurs both outside (local, regional, and legal

requirements) and inside the project organization. The alliance contract enables openness, encourages innovativeness, and frames the entire control package towards shared sustainability goals (Kivilä et al., 2017).

4.7.2 Contract Types

Choosing the proper contracting method can reduce the project duration, increase flexibility, reduce controversies, allow contractor participation in design, provide cost-saving incentives, and provide alternative financing methods. A contracting method has four parts: scope, organization, contract, and award. The scope is pre-defined because of the project itself (Gordon, 1994). The award process has already been described, while the organization is presented in the next section.

The traditional method sees a division of designer and general contractor with a fixed lump-sum contract. It offers control and linearity conducive to success if the project scope is clearly definable, with low chances of change (Gordon, 1994). Notwithstanding, modern projects do not fall in these criteria, and there should be room for modifications. Additionally, it is suitable for public procurement and TPPs but not PPPs. Nowadays, contracts fall into two main groups, namely, fixed-price and reimbursable, while a mix is called guaranteed maximum price (GMP). The decision should depend on risk allocation. A common approach is to allocate most of the risk to the contractors or consortium that will be incentivized to perform better because of the fixed price. However, a balance is recommended because one party can bear the risk at a lower cost based on its capabilities (see Risk Management section). The cost-plus option is also not recommended if not in situations when the costs can be easily controlled or when the price is not a constraint. GMP provides false security as it leans to one side or the other. Thus, incentives are recommended (Gordon, 1994).

4.7.3 Contract Content

While selecting contract strategies and type is fundamental, the content might change the final performance of the procurement. Legal consulting services will help identify the best solutions for both the contractors or consortium and the government. Grimsey and Lewis (2005) recommend that contracts be written as a flow of services rather than a construction process. Aerts et al. (2017) add that contractors should be allowed to modify the work packages as long as they do not modify the cash flow.

Kardes et al. (2013) suggest that clauses must include goals, rights, and obligations in any contract, even for the smaller ones. To this end, it is crucial to consider collaboration and select contractors and partners accurately, keeping in mind previous relationships and the level of trust. That way, it is also possible to share mutual interests and reduce the risks.

As per the general framework idea, contracts must contain sustainability concerns. Sustainability output specifications should not only rely on an "effort commitment" – which is an input – as such formulation often makes them unmeasurable or not enforceable. The governments, instead, should specify outputs that result in improving sustainability (Hueskes et al., 2017).

Economic and environmental indexes are easier to formulate when considering sustainability, while the social dimension is more challenging. Social aspects can be categorized into standards, assessments, codes of conduct, or guidelines. In addition, perceived outputs are good indicators of the perceived positive impacts. (Zamojska & Próchniak, 2017).

4.7.4 Recoup Money

Cost recovery is defined as the processes by which the public sector can file claims against the companies for negligence, errors, omissions, or poor quality (Greiman, 2013; Hatem, 1996). Given the large number of parts that compose an infrastructure, several contractors are often involved in the design and construction. Managers must recognize that some technical designs can be inconsistent with other designs or be simply flawed. To that end, the project management team must recognize the risks and act in advance with techniques to recoup money whenever possible (Greiman, 2013).

An example of a cost recovery process comes from Boston's Central Artery project, also referred to as the Big Dig. Greiman (2013) presents the lessons learned of that INFPRO and recommends cost recovery from the project front-end to the end, even later if some costs still have to be recouped. Moreover, the author highlights the importance of a cost recovery committee made of independent experts. Independence ensures that costs are recovered, avoiding conflicts and claims of impropriety.

Recouping money passes through contracts and legal documents. In fact, without proper precautions, improper costs might not be recovered. Clauses must be included, and, most importantly, all the stakeholders must understand the cost recovery processes. Clauses in the contracts also act as a message to designers, consultants, and others that they will be held

accountable (Greiman, 2013). To that end, a PMO can help train decision-makers in including such articles in contracts and legal documents, and assist in recouping money once a breach is identified.

Among the procurement methods, Siemiatycki (2010) found that PPPs increase the ability to recover money through cost recovery models.

4.7.5 Contractors Relationship Management

Contractors are within the stakeholders with the higher priority. They are the ones that execute the project. The government must keep the relationship with contractors or contractor consortia at the highest to ensure a spirit of openness and information sharing. Such a relationship is crucial as different strengths can be applied to solve problems when the public sector shares responsibility with the private one. Moreover, van Gestel et al. (2008) found that consensus between actors about the concept and the overall importance of the INFPRO can drive the project. They also argued that developing a network structure through informal deliberation and negotiation to find solutions and safeguard values can create dependency and trust between parties.

Verweij (2015) studied 27 Dutch road construction projects and found that cooperation usually has better outcomes than a focus on contracts. However, such a finding does not exclude the presence of contracts and rather detailed ones but emphasizes the importance of cooperation as the goal of contract management. If contracts cannot provide cooperation because of the negotiation process or because restrictions and clauses invite the parties to act with a too high degree of caution, then cooperation is hindered, and contracts do not reach one of their main goals (Verweij, 2015). Contract-focused relationships are not bad per se but work better in a straightforward and smaller size – not scope – projects like the addition of a highway lane. However, externally-oriented management still creates satisfactory results in smaller-scope projects (Verweij, 2015).

A potential threat to such cooperation is the lack of trust. To that end, previous relationships with the same partner will create benefits. For instance, if a consortium won a previous bidding process, the relationship increases relationship-specific investments. However, even a lost PPP bid generates positive spill-over effects (De Schepper et al., 2015).

4.8 Governance and Ethics

The government's role in megaprojects is not well-defined as it is a project promoter, active participant, regulator, and ultimate approval authority (Miller & Hobbs, 2005). Bruzelius et al. (2002) recommend that the public sector focus on engaging stakeholder groups, defining public interest and the regulatory regime, and promoting the project instead of being sovereign. The role of the private sector becomes using private risk capital and bidding more than one solution to meet objectives and requirements, as opposed to engaging in rent-seeking behaviors by hedging risks (Bruzelius et al., 2002; Rothengatter, 2008).

In megaprojects, and even more in INFPRO portfolios, a governance structure is not only beneficial but rather needed in such complex projects. In fact, the assumption that one party will assume the moral high ground has proved inappropriate (Miller & Hobbs, 2005).

This section presents recommendations for INFPRO governance. In this context, the PMO is the prime candidate to assume the control of such project management aspect, but all decision-makers should be aware of the governance structure

4.8.1 Governance Importance and Role

Governance should prevent and tackle many different problems and recognize the ever-changing stakeholder needs. In order to successfully deliver INFPROs, a robust coordinating role of the public sector is required (Greiman & Sclar, 2019; Hueskes et al., 2017). The government needs to keep the commercial performance concerns out of its governance responsibilities (Hodge & Greve, 2007). Governance becomes even more critical with PPPs. Given the sharing of risks, duties, and internal benefits between the public and private sectors, there is a need for a governance structure to ensure trust (De Schepper et al., 2014).

Governance should take care of both ‘real’ problems and those that are social constructs. Examples of the two categories include cost and benefits, and contested information, respectively (Sturup, 2009). Governance must consider that INFPROs might be cross-border – or cross-regional – projects. Therefore, there might be different normative, regulative, and cultural-cognitive institutions. The governance institution must anticipate such diversity and be creative in conducting operations (Orr & Scott, 2008).

The government must recognize that megaprojects are embedded in their institutional framework, and those projects with a solid instructional framework perform better in uncertainty. Additionally, megaprojects can even change the institutional framework – both regulatory and

legal (Miller & Hobbs, 2005). To that end, the government should define the regulatory regime for the project, including the ones on economic and financial performance and price regulation. Some argue that the government should decide whether to undertake a project, but it is easier to let the project itself decide, thanks to private interest and risk capital. In fact, risk capital entails less risk for taxpayers, more responsibility on the private sector, and possibly more involvement of the financer in the project's design, construction, and operation (Bruzelius et al., 2002).

4.8.2 Organization

The governance structure of the project can assume different shapes and deserves to be analyzed. This subsection presents some innovative ideas about organization theory, including from studies of some INFPROs, and then suggests an approach to build the governance structure.

Some scholars argue that any activity, if adequately divided, can be self-managed. That is also the case for INFPROs (Pryke et al., 2018). While that is not desirable for the whole INFPRO at the higher levels, clusters of stakeholders will inevitably create. Such clusters are self-organized, do not follow strict rules while still not random, and fall into the definition of system creating management complexity. However, since they are self-organized, they are stronger and more stable than a determined one. Furthermore, such clusters benefit from a high number of links that derive from the heavy reliance on communication. In short, these small worlds are more efficient. This phenomenon cannot be avoided or artificially made. Thus, management should not disappear but rather act as a catalyst. In fact, self-organized clusters make INFPROs robust and error-tolerant. Therefore, managers should tolerate lower levels and identify such clusters to foster them (Pryke et al., 2018). An example of how self-organizing clusters led to success can be found in the case of an underground rail-network station in London, UK (Pryke et al., 2018).

Rothengatter (2008) suggests creating a project company under private law and letting private investors bear part of the risks when legally possible. Such an organization can mitigate the negative political effects on the project. However, professional managers should oversee such companies, and former politicians should be prevented from doing so. When needed, the public sector can contribute by issuing grants, guarantees for loans and investments, fixed payments for particular user classes, free provision of access links, noncompetition agreement for competing projects in the future, and extension of the concession for additional services.

Greiman and Sclar (2019) list additional governance frameworks that INFPROs can implement, even concurrently: stakeholder advisory board, PPPs, PMO, project management, and joint venture.

It should be noted that the political administration will most likely change during the INFPRO life cycle, and that is an opportunity to transform the governance structure. Thus, choosing one governance structure that best fits initially is not advisable (Miller & Hobbs, 2005). Instead, Greiman and Sclar (2019) and Miller and Hobbs (2005) recommend defining a set of governance structures and implementing them for different phases – changing them as the project unfolds. At the outset of the project, it is possible to define governance criteria applied in every governance structure. Undoubtedly, with the experience and knowledge transfer, the ability to create governance structures will improve (Miller & Hobbs, 2005). Therefore, the previous structure might be conducive for one or more phases, but alternatives must be considered for other phases.

4.8.3 Monitoring and Controlling Approach

Monitoring and controlling can be integrated into the governance structure as it is one of the main tools to anticipate problems or successes and control them. The approach to monitoring and controlling in large projects like INFPROs requires a tailored approach.

Goals in megaprojects are somewhat dynamic, and both ex-ante assessment, ex-post evaluation, and ex-nunc monitoring are essential. The ex-ante should focus on pre-defined outputs and impact, which are better assessed through critical success factors (CSFs) and sustainability measures. The ex-post is important to evaluate factors that led to benefits, unexpected outcomes or effects, and the project's impact. It can focus on a company level, community level, or policy level. The difference with respect to the initial outcomes and the expected ones is explained by some CSFs that provide causality. The evaluation cannot provide causes for effects, but the evaluator can assess whether some CSFs are placed between randomization and program theory (Fahri et al., 2015).

4.8.4 Monitoring and Controlling

Monitoring and controlling rely on measurements of the work progress and impact on the sustainable dimensions. While for the work progress traditional project management can help with methods like earned value management (see the following subsection), indicators for the sustainable dimensions are difficult to choose and implement. However, project sustainability

governance is necessary to align the control mechanism with the sustainability goals (Kivilä et al., 2017; Oehlmann, 2010). This subsection presents suggestions to address such a problem.

Kivilä et al. (2017) state that sustainability goals must be added to the control mechanism rather than creating a new control mechanism just for sustainability goals. There are two approaches to sustainable development indexes: the framework approach and the aggregation approach. While the first creates problems in establishing the overall direction of the development, the second presents the difficulty in monetarizing sustainability values. A third approach includes creating standards and then calculating the gap (Ekins et al., 2008).

Sustainability can be included at a portfolio level or in the lower levels of the WBS in single projects. Overall, the government can design a Sustainability Management Plan and define its objectives with a Sustainability Breakdown Structure (SBS) that holds indicators relevant for each objective based on deliverables and connect to form higher-level objectives. SBS component should be linked to project deliverables. Following the same idea, there should be a sustainability accountability matrix or Sustainability Accounts (SA) that are accountable for the higher levels of the WBS and the lower of the SBS (Koke & Moehler, 2019).

Several indicators can be employed to create a framework that allows gauging sustainable development outcomes: input, output, result, and impact indicators; operational, specific, and global objectives; relevance, quantification, reliability, and criteria availability. Impacts alone are not sufficient as it might be challenging to estimate the causal relationships. Moreover, indicators can either relate to the stock or the flow of benefits (Ekins et al., 2008). Indicators can be found in a structured way. By considering the already four types of capital – manufactured, natural, human, and social – and dividing them into the capital flow and stock, there are eight different categories of indicators. Moreover, there will be inputs, outputs, results, and impacts for each combination. Besides, it is important to gauge the effect of policies in terms of synergies or conflicts with each of the eight types of indicators (Ekins, 1992; Ekins et al., 2008). Whatever the choice of the sustainability indicators, they must be case-specific rather than general ones, cover a specific area of sustainability, and meet the goals of various stakeholders. To that end, it is important to understand the perception of sustainability of each stakeholder and find common ground (Kivilä et al., 2017).

The Sustainable Footprint Methodology (SFM) has already been presented. It consists of creating a 3x3 matrix with the three pillars of sustainability on one dimension and the project

pre-phase, execution, and operations on the other, and then including sustainability indicators in each cell. SFM is to be seen as a system, and improving one indicator does not necessarily improve the whole system because of interdependencies (Oehlmann, 2010). Oehlmann (2010) proposes a 1 to 5 scale for qualitative indicators. Figure 4 below shows the five possible steps.

It is essential not to have a final value but to aim to have all the indicators high and throughout all the phases – not just at the end (Oehlmann, 2010). The SFM has already been tested successfully on a gas storage project in the Netherlands (Oehlmann, 2010).

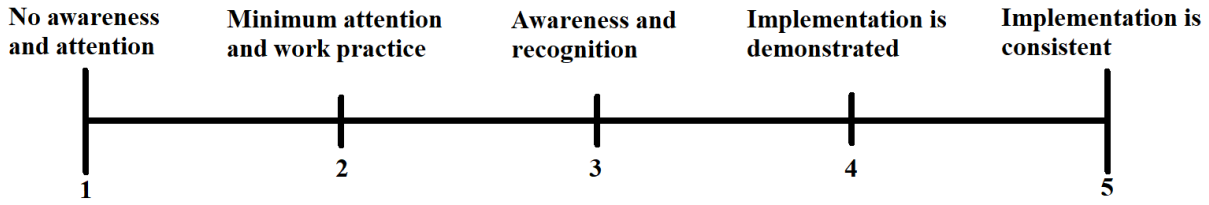

Figure 4 - Qualitative sustainability indicators' steps

4.8.5 INFPRO Earned Value Management

As aforementioned, one of the most popular approaches to monitoring and controlling is the use of Earned Value Management (EVM). Traditional EVM measures the progress of the project against the schedule and cost baseline using monetary values. Moreover, recent evolutions found that measuring the progress against the schedule and cost baseline using the schedule values is more effective (Tzaveas et al., 2010). It should be noted that EVM implementation is not trivial but requires top management and stakeholder support as there are resources requirements and sometimes even organizational structure and culture ones (Koke & Moehler, 2019).

Though EVM allows monitoring the value in terms of the iron triangle, sustainability matters are not included (Koke & Moehler, 2019). It is possible to develop a new framework called Earned Green Value Management (EGVM) and apply it at a portfolio level. The value now includes the Sustainability Value (SV), representing the added efficiency measured against past projects or other projects. The progress depends on the sustainability breakdown structure (SBS). The earning rules state that some can be calculated as absolute values in m^3, tons, and the like; others need leading or lagging indicators. Thus, performance no longer includes the iron triangle but the triple bottom line (Koke & Moehler, 2019).

4.8.6 Audits and Scrutiny

Any INFPRO requires audits and scrutiny. Given the difficulty of the technical side and the challenges of INFPRO management, audits help decision-makers with different and outside opinions.

It is important to include audits, especially for estimates. External auditors help reduce the effects of the so-called planning fallacy, using other projects to assess the quality of the initial estimates (Flyvbjerg, 2013). However, consultants are often hired by the project promoters, which biases their estimates. A technique involves multiple agencies for the pre-feasibility phase to increase competition and then reduces the number for the feasibility study to keep secrecy, applying bonuses or penalties based on the results of the next few years (Rothengatter, 2008).

Private funds encourage advisors and audits to protect the investments, undermining the lack of trust that is often the problem (Flyvbjerg, 2014). This is an additional reason why private financing improves cost estimations.

High-performing projects usually entail intensive scrutiny by the general public, and the project initiator should guarantee it. Political figures will rarely invite scrutiny as they enjoy control over decision-making (Miller & Hobbs, 2005). Scrutiny of the project budget is essential also at early phases as early scrutiny proved effective in enhancing the project performance (Miller & Hobbs, 2005). Miller and Hobbs (2005) recommend that scrutiny not be limited to the public sector but extended to the private.

All in all, both audits and scrutiny must be guaranteed for INFPROs as they provide value in terms of project efficiency, reducing potential cost overruns and, ultimately, the social cost. However, managers must balance excessive control, ruining collaboration with contractors (Kardes et al., 2013).

4.9 A Valuable Short-Term Win

Although the thesis advocates for a long-term and strategic perspective in the previous chapters, short-term and tactical successes are not to be forsaken. Kotter (2012) developed a model for change management and included short-term wins as a success booster. Since INFPROs bring change to the community, locals, and the government, it is important to manage the shift to the new normal, balancing short- and long-term successes (Katseff et al., 2020; Koke & Moehler, 2019). This concept applies to the single INFPROs and the portfolio.

Kotter (2012) advocates for early wins. In the author's definition, a win can be shaped as lessons learned, actions taken, and the like. Reasons for seeking and communicating short-term wins are to track the process and encourage the team. This follows an important pattern of agile development, that “teams that finish early accelerate faster” (Sutherland et al., 2014).

The author adds that showing early successes to stakeholders, particularly the community, can boost progress and reduce concerns and protests. Practitioners also mention that short-term pressures often provide relief and allow decision-making to focus on the long-term benefits (Reddy, 2020). Short-term wins at a portfolio level can also increase credibility, attracting bidders and capital for the next projects.

5. Operational Level

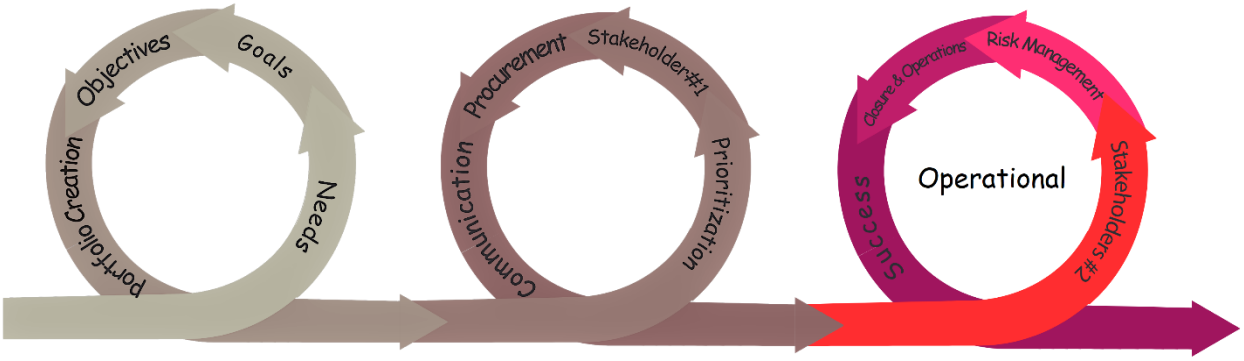

Figure 5 - INFPRO Framework, Highlight on the Operational Level

The Operational Level chapter presents the lower-level activities and approaches required for INFPROs. It touches on both the project implementation and the infrastructure operations. Given the peculiarity of each project, this framework does not explain how to manage a project but instead presents best practices that proved effective in past projects or have been proposed by scholars that studied the topic.

The project implementation and the following operations conclude the megaproject life cycle described by Priemus (2010). The infrastructure operations phase must come after a careful phase of project shaping – even if long – as it dramatically affects project success (Sato & de Freitas Chagas, 2014).

5.1 Realizing Value and Extra-Value

From the moment construction starts to the infrastructure operations, all project players must focus on realizing value. Given the importance of sustainability at the portfolio level, the project itself and the following operations cannot but implement sustainability principles. Moreover, some opportunities to realize an even higher value can emerge, and project players must recognize and exploit them.

5.1.1 Minding Sustainability

INFPROs tend to start to create sustainable value – both in the economic, social, and environmental dimensions. However, the initial benefits are often abandoned further into the project to achieve efficiency, transparency, and democracy (Kivilä et al., 2017; van Gestel et al., 2008). Project sustainability is forgotten while aiming at infrastructure sustainability. While

productivity creates value, it should not replace the project's longer-term sustainability goals, which contribute to the overall objectives and goals that satisfy community needs.

Project planning, execution, and control – including control mechanism and alliance contract of the project partners – must support project sustainability with sustainable choices in materials, working and workers conditions, the impact on the public, and economic and financial choices. To that end, the PMO must control such aspects to be aligned with the scores in the selection criteria of contractors or consortia and with the expectation for the project. A straightforward example of the social dimension of sustainability is providing the construction plan early allows to organize the traffic adaptation and minimize the impact on locals (Aerts et al., 2017).

5.2.2 Value Opportunity Exploitation

There are value opportunities in every project, meaning the potential to alter the quality and increase stakeholder value. Project value opportunities are situations when unplanned value can be created in the project execution or operation phase. Since megaprojects employ many resources and impact numerous people across generations, there might be many arising opportunities during the extensive infrastructure life cycle. Therefore, it becomes important that the project management team identifies opportunities for extra benefits. In fact, it is complicated to identify and evaluate all benefits ex-ante (Eskerod et al., 2018; Greiman & Sclar, 2019; Lechler et al., 2013). Such opportunities might arise up to the operations phase of the INFPRO (Eskerod et al., 2018; Greiman & Sclar, 2019).

When there are unexpected situations or uncertainty, there is room for unexpected benefits and value or creating additional value out of the expected benefits. However, the project management team and even stakeholders must be ready to detect the conducive moment and exploit the situation. In fact, unexpected benefits do not materialize by themselves (Eskerod et al., 2018). Eskerod et al. (2018) suggest that the earlier the project captures various stakeholders' views, the better to maximize opportunities.

The Astoria-Megler bridge between the states of Washington and Oregon in the US explains this concept. The INFPRO started among the general unbelief of citizens and was ridiculed as it was considered a waste of taxpayers' money. However, it became appreciated over time, especially as opportunities were exploited. Since its construction, it created unexpected benefits, such as creating a higher number of jobs, connecting people to places and sustaining

economic growth, and transforming the surroundings, among others. Moreover, it was used for unplanned scopes, creating additional value: carrying fiber-optic cables, gathering runners, shooting movies, and researching light. Moreover, tolls were removed once the project cost was repaid. On top of all the above, there are two planned benefits: time-saving and convenience. The project also brought disbenefits like the closure of a ferry and loss of clientele for the related businesses. It is interesting to notice that external parties such as locals and businesses found unexpected uses of the bridge and brought benefits. By exploiting project value opportunities, the generated benefits do not decrease over the years but rather increase (Eskerod et al., 2018).

The discussion above entails the involvement of stakeholders. However, for stakeholders to participate, it is essential to engage them and be patient as some opportunities will only emerge during the operations phase. Furthermore, celebrating achievements will result in a higher level of stakeholder interest and a higher number of opportunities. The section below provides suggestions on how to manage stakeholders and support value opportunities exploitation.

5.2 Stakeholder Management

While stakeholders are involved long before the project start, they are active during the project execution and even after the completion and during operations. Therefore, the project management team must craft a sound stakeholder management plan that includes collaboration with the private sector.

5.2.1 Stakeholder Management (SM)

Stakeholders can be managed in two different ways: reactively or proactively. Often problems arise in INFPROs when there is an unbalance between the two. Both excessive proactiveness and complete reactiveness are dangerous. In PPPs, the public and private sectors share the project management functions. Therefore, the private consortium can give different attention to stakeholders than the public and exert different power (De Schepper et al., 2014). For instance, De Schepper et al. (2014) argue that shareholders are involved more proactively when the private consortium is responsible for SM. Thus, a shared responsibility can be successful, but it has to consider the stakeholder dynamics (De Schepper et al., 2014). Since stakeholders differ in different phases, stakeholder management should change during phases (Zeng et al., 2015).

Stakeholders can also differ in different phases. An anchor-tenant, i.e., the Most Valuable Stakeholder (MVS), can be identified for each phase. The MVS influences the approach of the other stakeholders in the same phase, for instance, whether formal – which is related to laws and regulations – or informal – based on norms and culture (South et al., 2018). The role of SM is not to wait for the MVSs of the following phases to reveal themselves but to identify them as early as possible. That is the case because engaging them at the beginning can enhance results and decrease protests (South et al., 2018).

All stakeholders potentially influence or are influenced by other stakeholders dynamically during the project. That is why models like stakeholder networks have emerged in recent years. In order to successfully manage INFPROs, identifying and analyzing the stakeholder network at different times plays an important role in INFPROs (De Schepper et al., 2014; Miller & Hobbs, 2005; Mok et al., 2015; Mok et al., 2017). The reason is that not only do stakeholders have networks, but INFPROs are a network of interrelated stakeholder concerns. If a concern is not addressed, it can lead others (Miller & Hobbs, 2005; Mok et al., 2017).

While media might be initially disregarded, they are a powerful instrument that can and will influence stakeholders (Olander & Landin, 2005). The idea is not to consider censorship, but the opposite. Inviting media to the site and keeping the public updated with transparency is crucial (see the next subsection).

5.2.2 Stakeholder Engagement

From the previous chapters and sections, stakeholder engagement emerges as a vital activity in INFPROs. General approaches to engaging stakeholders have already been presented, but additional aspects deserve particular attention.

An aspect of stakeholder engagement is that it is possible to communicate the value of the INFPRO. To that end, it has already been presented the importance of several channels to address different stakeholders. However, Social Relation Management should focus mainly on those stakeholders that perceive the outputs to a greater extent. That is the cause because there is a positive relationship with the perceived positive outcomes Zamojska and Próchniak (2017).

Giezen (2012) suggests a comprehensive social environment management strategy – e.g., visits to the construction site – to address the concerns and protests of the negatively affected locals. The previously mentioned East Line Subway in Amsterdam is an example. After the protests and the referendum, the project promoters' approach to stakeholder engagement

changed. Communication was reshaped, and the team emphasized common values such as environment, inclusiveness, and openness. Additionally, videos, photos, project excursions, and others were published and changed public perspectives. Ceremonial events were initially disregarded, but they proved effective when the communication strategy changed. A final touch was assigning human names to the boring machines, which "humanized" the tools, closing the gap between humans and machines by increasing empathy (van den Ende & van Marrewijk, 2019).

Overall, the approach to stakeholder engagement must be genuine, ensuring transparency, and collecting ideas for project value opportunities from any stakeholder. That does not automatically translate into implementing such ideas, but decision-makers should consider them. The presence of websites, news on different media, open site visits, and other initiatives can improve the relationship with all stakeholders, particularly with the locals and general public.

5.3 Risk Management

Risks are defined as the possibility that events will not follow the plan and turn out differently than planned (Kardes et al., 2013; Miller & Lessard, 2007). That means that risks can positively or negatively affect project success (Project Management Institute, 2017). Megaprojects are inherently complex, and they bear high risks. Consequently, appropriate risk management is required (Kardes et al., 2013). Risk management proved effective in INFPROs as it enhances project success and market viability (Greiman, 2013; Lam, 1999; Little, 2011; Miller & Hobbs, 2006). Not all scholars agree on the effectiveness of risk management as often results were unsatisfactory and did not bring the expected benefits (Boateng et al., 2017). Zhao et al. (2014) found that employing additional resources for risk management usually does not result in better outcomes. Flyvbjerg, Bruzelius, et al. (2003) summarize that megaprojects can better deal with risks once they are explicitly acknowledged and managed with accountability, highlighting the importance of risk management.

Surprisingly, megaprojects often lack a thoughtful risk analysis attributed to institutional aspects (Bruzelius et al., 2002). Notwithstanding such deficiency, managing risks is essential as INFPROs last even decades (Shen et al., 2006). Duration is also one of the reasons for the high level of uncertainty. The difference between risks and uncertainty is the sense that risks' probability can be gauged (Kardes et al., 2013).

This section presents INFPRO risk management processes and recommendations, including common risks, a risk management framework, the importance of gauging the overall risk, and risk sharing in PPPs.

5.3.1 Assessing Overall Infrastructure Risk

The concept of overall risk appears in PMI's standards for project management and project risk management. The concept has been defined as "the effect of uncertainty that affects organizational objectives at different levels or aspects" (Project Management Institute, 2017, 2019) or "the exposure of stakeholders to the consequences of variations in outcome" (Association for Project Management, 2004, 2012). Assessing overall project risk is a form of implicit risk management and allows the categorization of the project riskiness even in the pre-project phases. Overall risk is an important concept because it does not require a detailed risk identification process but gathers the potential effects in one single concept. Overall project riskiness can be assessed at different points in time to analyze the trend. The analysis can be conducted using frameworks such as the PESTLE analysis, SWOT analysis, Ishikawa diagram, or VUCA analysis. Additionally, techniques like Delphi can improve the results (Hillson, 2014).

There are two main dimensions of overall risks based on the definition of the concept presented above: uncertainty and significance. Therefore, a matrix can show where the overall risk stands and even identify the evolution over time (Hillson, 2014).

While qualitative analyses can communicate the general idea, a quantitative approach is recommended. For instance, INFPROs overall project risk can be assessed using Monte Carlo analysis. Its output shows several possible outcomes and their probability, creating a cumulative probability "S-curve". The approach is suitable for both time and cost but can also be applied to performance, return on investment (ROI), and similar. However, when both cost and time are considered, they can be plotted, creating a chart with cost and time, where data's shape is usually an eyeball – from which the term "eyeball plot" derives. Stakeholders can see the results, analyze the range – minimum and maximum time, minimum and maximum cost. The eyeball orientation also shows the potential relation between cost and time (Hillson, 2014).

There are several reasons to undertake an overall project risk analysis before and during the project. If the overall risk is more than the accepted level – which the government and contractors decide in advance, the project should not take place, at least in the time frame when the analysis is conducted. Another reason is that the major causes for such levels are identified

and can be carefully managed. Furthermore, the trend during the project indicates whether the overall project risk is quickly reaching an unacceptable level of uncertainty and significance that requires pausing the project. Finally, the (presumed) best and worst cases are known, allowing enough management reserves (Hillson, 2014).

The method recalls some concepts of reference class forecasting (RCF). However, they are very different concepts. RCF allows proper planning, taking an outside view. Overall risk, instead, calculates the time and cost ranges using project-specific knowledge. Moreover, the overall risk is dynamic and changes throughout the project.

5.3.2 Risk Categories and Strategies

The first step for risks management is identifying risks. To help practitioners in such a task, scholars have created risks categories. Most risks fall under those categories and guide risk identification as each category can be expanded to identify lower-level risks. Table 9 below summarizes different types of categorizations from academic literature.

Author(s)	Categorization Type	Categorization
Kardes et al. (2013)	By causing factors	- macro risks are related to non-project-related exogenous factors, having an indirect impact on the success. - micro risks are endogenous and directly result from internal project factors such as management team, and stakeholders
Kardes et al. (2013)	By causing factors	- technical and operational risks, - market risks, and - institutional or social risks
Bruzelius et al. (2002)	By impact area	- cost, - demand, - financial market, and - political risk
Shen et al. (2006)	By causing agent	- project-related,

Author(s)	Categorization Type	Categorization
		- government-related, - client-related, - design-related, - contractor-related, - consultant-related, and - market-related

Table 9 - Categorizations of INFPRO risks

Once risks are identified, a strategy must be crafted (Project Management Institute, 2017). Strategies for risk management include decision-making and risk assessment, creating strategic systems (e.g., for information gathering, maintaining competency, allocate resources), governability, influencing institutions (e.g., the transformation of laws and regulations), having risks portfolio to diversify risks, and embracing residual risks (Kardes et al., 2013; Miller & Lessard, 2007).

Generally speaking, risk management must have an integrated approach, including its processes in the INFPRO plan, crafting an overall strategy for different problems, and being capable of adapting to changes. The need for the adaptation character of risk management derives from the uncertainty that reigns in megaprojects.

5.3.3 An INFPRO Risk Management Framework

INFPRO risk management follows the flow of the standard risk management processes. However, special techniques can apply, and additional points are touched on (Greiman, 2013).

As the overall INFPRO management can benefit from a framework, scholars have crafted frameworks for specific parts of INFPRO management. It is the case of Kardes et al. (2013) that proposed a framework for risk management. It is a continuous cycle that starts with defining risks and continues with assessing and quantifying risks, determining risk response strategies, implementing, and eventually monitoring and updating. All of the above depends on the strategic goals – strategic, operational, reporting, and compliance – that derive from the goals and visions of the INFPRO. As inputs, there are also culture, resources, the information flow system, contractual agreements and treaties, and partners and stakeholders.

5.3.4 Sharing Risks with PPPs

As aforementioned, one of the main advantages of PPPs is risk-sharing. The private and public sectors allocate risks to one party to better control risks and respond more effectively. PPPs' risk allocation depends on what sector has the best knowledge and resources to address them (Kwak et al., 2009; Sturup, 2009). However, Sturup (2009) states that such sharing works because risks are both threats and good risks. Thus, risk-sharing can provide returns. Unfortunately, there is no guarantee that it will be the case and that the most competent party will successfully manage the allocated risk, especially if there is a risk premium without a specific measurement attached (Sturup, 2009). In fact, it is often the case that risks are allocated, but the only requirement is the effort rather than successfully managing the risk.

Risks sharing must follow a process. As a matter of fact, allocation cannot start without proper risk identification and negotiation for the allocation. Collaboration to tackle the same risks is an option.

The creation of a new entertainment park in Hong Kong is an example of risk-sharing in PPPs. Risks were first identified and then allocated. The site risks were divided between the public and the private sectors by assigning the land acquisition risks to the former and the risks associated with existing buildings to the latter. Moreover, some specific risks like the underground ones were not fully assigned to either (Shen et al., 2006).

5.3.5 Common Risks in Megaprojects

INFPROs are not made because of a mere financial or speculative gain. Hence, the risks are not limited to financials (Shen et al., 2006). Much of the risks of a PPP project come from the complexity and uncertainty of the arrangement in terms of financing, taxation, technical details, and market conditions. among others. Moreover, all these aspects become even riskier as they change throughout the project (Shen et al., 2006). This subsection presents INFPRO-specific risks that rarely appear in other projects.

The importance of politics for INFPROs has already been presented in the first chapters. However, political involvement implies potential risks. In fact, given the high political interest, the number of involved organizations, and the bidding processes, there is a high risk of corruption (Zeng et al., 2015).

Because INFPROs require the movement of many workers into a relatively limited space, the spread of diseases presents a potential risk (Gellert & Lynch, 2003). Such consideration

assumes even more importance considering the recent COVID-19 pandemic and the potential effects on occupational safety. However, diseases are not the only threat, and the work environment can lead to different illnesses due to working conditions, air quality, noise pollution, and others (Zeng et al., 2015).

Previous sections already touched on the financial aspects of such large investments as INPROs require a high return. Significant investments bear high financial risks. Nonetheless, the public sector can lower them by allowing private financing (Shen et al., 2006). That implies that PPPs have the potential to lower financial risks by bringing private funding. When private institutions finance the INFPROs, they require interest rates, and the same holds when contractors or consortia's companies require loans. This reveals another important macroeconomics risk: interest rate fluctuation (Tang et al., 2010).

Any relationship with contractors also carries risks. To that end, Shen et al. (2006) recommend that payments be made at the completion of specific milestones to reduce the contractor-related risks. Nevertheless, payments are not the only risks. A crucial aspect of risk management in megaprojects is to examine the supply chain as it is often a multi-country and multi-layered chain (Project Management Institute, 2017). Potential problems with the supply chain of innovative technologies have already been highlighted in previous sections, but any supply chain can cause delays, reduce quality, and increase costs, among others. Therefore, the supply chain risks must be managed with greater attention in INFPROs because of the many layers and cross-border dynamics.

Relationships with several contractors can also create integration issues (Greiman, 2013). While the public sector does not bear the risk, especially in TPPs and PPPs, the project can experience delays and additional costs. Communication with contractors or consortia is paramount to avoid that.

While relationships with contractors might create risks, the same relationships can benefit risk management. Guo et al. (2014) analyzed two case studies and found that an alliance model and INFPRO governance enhance risk management success. The alliance model creates risk ownership that results in risk sharing with a joint effort in managing them. Governance, instead, enables a faster response to the materialization of risks.

Relationships with society create risks. Infrastructure projects are made for the community and influence people's lives directly and indirectly. Protests and other types of so-called social risks

have already been presented. However, the general opposition to the project and general discontent with the project execution can cause delays. For instance, an interruption of a transportation infrastructure project can influence traffic. Even the interruption of a project can cause discontent (Li et al., 2021).

A final risk type in INFPROs is natural disasters because of their extension. Most infrastructures are exposed to natural hazards like sea level and temperature. This is a product risk that must be addressed in advance rather than responding during the infrastructure operations through maintenance. Therefore, creating a natural hazards-resilient design is crucial as the risk will increase with time (Willis et al., 2016). Even if force majeure is not one of the higher probability risks, it must always be present in megaprojects risk management (Walter, 2016).

5.3.6 General INFPRO Risk Management Recommendations

Most scholars argue that risk management in INFPROs succeeds if it has been planned and accepted by stakeholders. Moreover, every risk area must be allocated to a responsible, and risk management must extend throughout the whole life cycle. Risk management must be strategical and start from the top management. The role of risk management in INFPROs is not to actively mitigate or remove all risks but must balance cost, benefit, and alignment – both internal and external – with constraints and priorities. In short, successful INFPRO risk management comes from an integrated approach (Greiman, 2013; Miller & Hobbs, 2006; Project Management Institute, 2019).

Miller and Lessard (2007) proposed six approaches to risk management for INFPROs: planning and calculating risk management, creating a strategic system to address risks with project-specific strategies, instilling governability in the decisions to identify the correct choice *a priori*, creating laws and regulations to anchor the teams to the economic, political, and social contexts, diversifying the portfolio, and embracing the residual risks.

Kardes et al. (2013) presented general recommendations for INFPRO risk management. The starting point is having a talented pool of managers and directors that allocates time to clarify goals and their interpretation. Then, contracts should include goals, rights, and obligations for all the parties to avoid moral hazards and maintain long-lasting partnerships between the parties. Previous collaborations with the other parties might be a success factor even more than contracts. Additionally, the authors suggest more transparency to reduce the illusion-of-control effect and create a spirit of collaboration for success. Control and commitment are also identified

as success factors. Finally, they recommend starting with a viable idea and then shaping the project as presented in this framework.

Furthermore, INFPROs depend on many different factors, including contractors and their market and environment. To address changing markets, scenario and sensitivity analysis can be performed to safeguard flexibility, even if complete protection is impossible. Instead, when insurances are available, transferring the changing market risks is an option (Priemus, 2010).

5.3.7 INFPRO Risk Management Techniques

INFPRO's extent and complexity require advanced techniques for risk management, including its quantitative sides. Statistical techniques are often a solution. Statistical distribution and probabilities of schedule and budget increase the quality of risk assessments. However, they do not allow lessons learned because everything is summarized in numbers. Therefore, other frameworks have appeared in the academic literature to cope with such problems.

SDANP framework is one of the potential solutions. It combines two techniques – SD and ANP, described below – to create an integrated use of statistical techniques. The framework stored information in a database that automatically and constantly updates based on the newly identified and analyzed risks. The iterative process prioritizes risks using the Analytical Network Process (ANP) – which recalls the Analytical Hierarchical Process (AHP). Then. A technique called System Dynamic (SD) models data over time. The strengths of SDANP are that it considers the interrelationships among different types of risk, updates as risks update throughout the whole project, and stores data for lessons learned (Boateng et al., 2017; Lyneis & Ford, 2007). See Boateng (2014) or Boateng et al. (2017) for the SDANP's flow chart.

Artificial Intelligence (AI) is one of the latest trends in megaproject risk management. It has several applications. For instance, it can be utilized for occupational safety and quality control. One of the subcategories of AI is Natural Language Processing (NLP). This technology sees its application in recognizing potential risks in contract formations. Indeed, it recognizes words and finds potential threats. A downside is that AI raises ethical questions, and its implementation is challenging (Greiman, 2020).

In order to craft a proper risk response, megaprojects must address the root cause of the risks. To that end, project or program managers must conduct root-cause analyses. The result of such effort is a deeper understanding of the most profound causes of the risk. Once the root cause is tackled with proper risk management, the risk is minimized. Moreover, the same root cause might start several

risks, even some not included in the risk register. Therefore, the root cause analysis unveils new positive or negative effects on the projects to update the risk management plan (Greiman, 2013).

There are also techniques for social risk. Li et al. (2021) developed a computational simulation model using an agent-based approach. The model simulates the evolution of social risk throughout the project considering the social network among stakeholders and developing possible scenarios with the what-if analysis. That way, managers can decide how to manage the risk throughout the megaproject life cycle properly.

5.4 Use of Technology

Technology plays a central role in megaprojects. Not only is it included in INFPROs as part of the innovativeness and best practices, but it can also help the project management team. Affected areas include project monitoring and control, risk management, and communication management. Moreover, some practitioners suggest that digital solutions can speed up the design, procurement, and construction of INFPROs by using a collaborative environment (Beach, 2021). Managers must recognize the importance of technology to address megaproject complexity. To that end, training the project personnel becomes a way to reduce the impact of such complexity (Marler et al., 2006).

Many technological tools can be used in INFPROs. Discrete-event simulation is one of them, and it is used to estimate the costs and performance. The presence of the time sequence is one of the main advantages of this tool. It works both for the implementation of the project and the operations of the product. Additionally, it serves as training and education for project managers. Discrete-event simulation can also be used for project scope management. Simulation prevents useless investments, gauges the suitable capacity to avoid extra costs, allows learning about the project before something happens – including the operations phase, and reveals potential solutions to maximize the value of the investment. Simulation can be applied during different phases of the project life cycle and requires a strategic view to manage project scope. (Artto et al., 2001).

In terms of construction aids, a Building Information Modelling (BIM) model can facilitate collaborative knowledge management. It is a virtual model of the infrastructure that allows to survey the 3-D static model and provide up-to-date information – becoming 4D with the inclusion of time – about parameters that are received over time (Eastman et al., 2011). For instance, Internet of Things (IoT) devices can provide data about the humidity of the road in a

bridge, the tension of some supporting cords, the pressure on a highway pillar, and the like are communicated in real-time and integrated into the BIM model. However, BIM applications in megaprojects are challenging as it requires advanced integration of different construction types. It is the case, for example, of the Instanbul Grand Airport project that required the integration of terminals, railways, roads, and the like. Despite the additional effort, BIM improves monitoring and control processes, enhances collaboration among contractors in the design and construction phases, reduces waste, and shortens problem-solving processes (Keskin et al., 2019).

The use of Artificial intelligence (AI) has already been mentioned in the risk management section as it provides benefits in terms of risk identification, occupational safety, and quality control, among others (Greiman, 2020). AI is changing project management, and 52% of professionals see AI as a digital assistant within the next five years. Moreover, 78% of them consider machine learning an essential tool. Many practitioners consider it helpful for time, quality, and transformation, improving productivity, decision-making, and performance (International Project Management Association, 2021). INFPROs must use any help that minimizes repetitive tasks and increases efficiency and efficacy through AI. Some application areas might not be suitable for unsupervised AI decision-making, but the technology can still provide insights that professionals can use.

Big data complements AI for occupation safety. It is possible to use predictive models to anticipate potential incidents that, more than any mere cost overrun, might cause the loss of lives. Ayhan and Tokdemir (2019) analyzed AI-based models and found promising results in the application as, in the specific case, they predicted 86.67% of fatal incidents. Moreover, models are also capable of adapting to new entries. Clearly, this solution requires many data, and the portfolio structure – and PMO – can help with data collection.

5.5 Project Closure and Operations

The efforts of the project team culminate with the project closure. This is the time when the construction phase is concluded, and the infrastructure can start its operations. However, defining when INFPROs end is no easy task as it quickly shifts to operations (Sato & de Freitas Chagas, 2014). Moreover, some INFPROs might start their operations while the construction is still in progress, e.g., a section of a highway may be already in place, and users can benefit from it even if the whole project has not come to an end yet. Thinking of INFPROs closure as a

defined date is impractical and creates problems assessing the project success (Sato & de Freitas Chagas, 2014). Instead, it is more convenient to think of the project closure as the handoff to the infrastructure operator.

One of the criticalities of INFPROs closure is that many workers find themselves without a job, increasing the supply in the area and decreasing demand, with a consequent decrease in the labor price (Gellert & Lynch, 2003). That should be considered to implement sustainability – particularly the social dimension – even in the closure phase. To that end, governments must implement adequate measures to avoid social and economic disbenefits.

Project closure is the "passing of the torch" to infrastructure operations. As one of the last phases in megaprojects, the project is delivered and offered to the defined operator – either a selected contractor in TPPs or a consortium company in PPPs. This phase is fundamental to project success (see next section) as the market changes in the meantime. The environment can shift, positively or negatively impacting the expected usage of the infrastructure. The operator must conduct day-to-day tasks that include running the infrastructure, e.g., collecting tools – and performing maintenance works to ensure usability. Moreover, it must encourage usage through user engagement. Instead, if the reaction to the infrastructure is not favorable, the project initiator can intervene and restructure the project to prevent imminent failure (Miller & Hobbs, 2005).

5.6 Success

The perception of project success by stakeholders has little to do with scope, time, and cost. The iron triangle is not a good indicator of project success. In fact, project success can be perceived differently by different stakeholders at different times (Moehler et al., 2018; Turner & Zolin, 2012).

There are several ways in which stakeholders measure success, and the project team should forecast them. Indicators of project success are divided into project success and stakeholder satisfaction: (project success) planning, stakeholder engagement, (stakeholder satisfaction) stakeholder satisfaction, executive satisfaction, product satisfaction, product efficiency, satisfaction with specialization, project management satisfaction, contractor satisfaction, supplier profitability, and public stakeholder satisfaction (Turner & Zolin, 2012).

Performance criteria should be defined in advance. They must focus on value (see above), objectives, and benefits. The latter must be derived from policy objectives and public interest requirements rather than technical aspects (Bruzelius et al., 2002).

Measuring project success is a challenging task per se. However, it requires several assessments throughout the different phases of INFPROs and operations. Success in megaprojects can assume five dimensions: efficiency, impact on customers, impact on the team, business and direct success, and preparation for the future. Therefore, different stakeholders can measure project success in the short, medium, and long periods. Success in megaprojects must be appreciated long after the project close-out phase as the outputs and outcomes cannot be separated for performance assessment. (Fahri et al., 2015; Sato & de Freitas Chagas, 2014).

In order to accommodate the evaluation of benefits that emerge even long after the project end, Priemus (2010) proposed a different phase for megaprojects. That is the case of post-project evaluation, which is often mistakenly limited to assessing how the project followed the plan. In fact, team members have already been released from their roles, and the phase is usually handled as a mere formality. The final project success emerges once the benefits are achieved and have a strategic impact rather than a tactical one. Moreover, benefits also include the unintended ones. This is why outcomes are not outputs, and outcomes analysis provides a better view of benefits (Fahri et al., 2015). Consequently, it is recommended that the project success be constantly evaluated during infrastructure operations, with the PMO leading the process and making every effort to involve the team and perform a thorough post-project evaluation.

6. Conclusions and Limitations

6.1 Conclusions

The main goal of the thesis was to craft a framework that can guide public infrastructure construction project (INFPRO) practitioners in the management of such challenging projects. The methodology consisted of organizing the current academic literature and giving a structure and sequence to the main topics that practitioners must consider.

The thesis first presented the framework and then explained the rationale for such a structure, presenting all the knowledge from scholarly works that contributed to the organization of the knowledge. The INFPRO framework was divided into three main levels: strategic, tactical, and operational. Each contains several topics that can only be addressed if the previous phase produced its outputs – the inputs of the next phase. Moreover, each phase presented additional points that touch on external factors that can influence decisions.

The strategic level starts with defining the needs that the initiative will address, as derived from the needs of the citizens and the country as a whole. Then, needs are converted into strategic goals and turned into measurable objectives that contribute to achieving goals. Finally, the phase prescribes the collection of ideas for potential INFPROs coming from various stakeholders, including but not limited to politicians, citizens, companies, and local governments. Those projects will be inserted in the INFPRO portfolio that will be the main structure to manage several projects. This structure will have its own strategy for fulfilling the strategic objectives. Additionally, the strategic level touches on the importance of a long-term perspective, emphasizing the importance of sustainability and sustainable project management. The level also presents benefits realization management (BRM) that plans for benefits and assures their realization with reviews and measurements. Furthermore, cultural and geopolitical aspects are identified as inputs for the selection of the approach. Finally, the strategic level prescribes the creation of a national portfolio management office (PMO) to coordinate activities and encourage knowledge transfer. Moreover, it allows for better risk management and communication, and other project and portfolio management activities.

The tactical level is the richest one and presents several topics summarized in project prioritization, stakeholder involvement, procurement process, and communication management. While the portfolio already contains some projects, not all projects can concurrently occur due to capacity and capital constraints. Therefore, the projects with the higher value must be prioritized.

A portfolio allows for the insertion of additional projects even if it has already started, calling for a dynamic prioritization. Once projects are assessed and prioritized, the government must evaluate whether it is the right time, as several factors influence the decision. The public sector must encourage stakeholder participation to voice concerns, ideas, and similar for the co-design. This allows for early prevention of potential protests and a timely engagement of negatively impacted locals. Once the project is refined, the public initiator must decide which procurement method better fits the project – or decide it at a portfolio level – and start the procurement process. Moreover, it is essential to craft both a contract and a contractor management strategy. Once contractors or the contractor consortium have been selected, the communication plan must be crafted as it plays a crucial role in INFPROs. Additionally, the tactical level requires different inputs. The first is the INFPRO environment and approaches, including the importance of modularity and speed, political support, and the general megaproject life cycle. Then, the tactical level requires governance that keeps all the areas together. The environment must comply with the highest ethical standards and provide transparency. The last recommendation at a tactical level is to seek an early win. This is important because many change management frameworks highlight its importance and boost the chances of other successes.

Finally, the operational level presents specific techniques for stakeholder management during INFPROs and risk management. Moreover, it introduces the importance of project closure and operations in INFPROs. The concluding topic is project success. While it is the last step in the framework, it is required as it is the primary goal of each project in the portfolio to succeed. It provides benefits that, together, help achieve the strategic objectives and thus the goals. Through this, the status quo changes, and the gap with the vision and satisfaction of needs shrinks. The operational level also provides insights on the importance of the value realization during the project itself. It highlights the centrality of finding and exploiting project value opportunities, even during project operations. Moreover, it touches on the use of technology to ease the technical challenges and improve the chances of success.

Overall, this thesis contributes to the academic literature by organizing and structuring available knowledge into a usable framework. This thesis is the first attempt to design an INFPRO framework to the best of the author's knowledge. Therefore, this is the main contribution. Additionally, the framework presents the idea of infrastructure and agility. While

the thesis does not advocate for the use of an Agile methodology, it supports an agile mindset in infrastructure development, which is an additional contribution to INFPRO knowledge.

6.2 Implications

The INFPRO framework has several implications for both practitioners and scholars. Since this is the first attempt to craft an INFPRO framework to the best of the author's knowledge, scholars should analyze the solution and provide feedback and criticism. The author recognizes the challenges of INFPROs, the extensiveness of the topic, and the resulting impossibility of designing a perfect framework. Therefore, academic literature is encouraged to pursue the framework idea, modify the presented framework or create additional frameworks to improve INFPRO management continually. Indeed, it was within the scope of the thesis to create interest in the topic and encourage scholars to create better frameworks for practitioners. Moreover, the work calls for an extensive analysis of agile practices in infrastructure development.

Practitioners, instead, are encouraged to make use of the framework, especially in following the three levels and iteratively improving decisions. To that end, implications include:

- Following the three levels: planning first the strategic level, then using the outputs for the tactical level, and ultimately for the operational level.
- Have a long-term perspective due to the duration of infrastructures and the even more prolonged duration of the INFPRO portfolio.
- Create a public portfolio management office (PMO) or adapt an existing institution.
- Consider cultural and geopolitical aspects when crafting the strategic goals, objectives, and portfolio.
- Familiarize with the IFNPROs environment through: making extensive use of the knowledge management; training before starting the decision-making processes; learning about effective decision-making and leadership in megaprojects; considering the importance of modularity and speed; gaining political support, and developing system thinking.
- Analyze and implement value assessment processes for the selection of the right projects at the right time.

- Involve stakeholders early in the decision-making process, even before the project initiation.
- Choose a procurement method that fits the project or at a portfolio level, and then correctly craft the procurement process, engaging bidders, and selecting the right contractors.
- Manage contracts and contractors thoroughly.
- Design the communication strategy at a tactical level, implementing the value of transparency in any communication.
- Create a governance structure that reinforces support for both the public and private sectors in the project. That requires extensive use of monitoring and control, new forms of earned value management, audits and scrutiny, and opening to lower-level self-organization to improve efficiency.
- Seek a valuable early win to encourage change and increase portfolio acceptance.
- Focus on sustainable value during project execution.
- Identify and exploit extra project value opportunities as they arise, collecting ideas from stakeholders even during the infrastructure operations phase.
- Manage stakeholders throughout the project, engaging them with transparency.
- Manage risks by identifying all types of risks, from the general to the INFPRO specific, using the proposed INFPRO risk management framework, and sharing risks with the private sector if the procurement method is the public-private partnership (PPPs).
- Use technology as much as possible to help the project management team be more efficient and effective, using artificial intelligence, data analytics, simulations, and others for planning, risk management, monitoring and control, and communication management.
- Properly handle the project hand-off. This requires the passing of the torch even before the conclusion of the construction whenever possible.
- Assess success several times during the project, focusing on the delivery of stakeholder and sustainable value, and evaluating the final success after the start of infrastructure operations.

6.3 Limitations and Future Research

This thesis presents some limitations. First, it only considers public infrastructure construction projects and not any infrastructure project. Considering the trend to implement ICT infrastructure, e.g., for the public administration, different aspects might be integrated into the framework and extend its validity to other infrastructure projects.

Second, it only considers the government's standpoint, leaving a gap in the knowledge from the private sector's standpoint. Clearly, companies do not run the whole infrastructure project, so there is no need for such a framework for them. However, the role of the private sector appears from the tactical level, and recommendations for them can improve the final result of INFPROs. Future articles can address this perspective, using the framework as a basis for considerations.

One of the main limitations remains the lack of any empirical element, which is left to future research. While collecting data on infrastructure portfolios remains challenging because of infrastructure projects and portfolio significant durations, practitioners can endorse the framework, criticize it, and recommend modifications. Scholars can also analyze case studies to verify the validity of the tactical level and operational level, even if the strategic level is not considered.

Finally, the framework does not include considerations about policies or managerial incentives as it works at a higher level. However, policies and managerial incentives play an important role in INFPROs. Different literature already addresses the problem, and the topic can be integrated if needed. As previously mentioned, the author expects improvements of the model as many other topics have not been included, focusing on higher-level concepts.

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Figures

Figure 6

Chain of benefits (Serra & Kunc, 2015).