

MÁSTER UNIVERSITARIO EN DIRECCIÓN DE PROYECTOS

TRABAJO FIN DE MASTER

< TREATMENT, COMPARISON AND NEW PROCESSES PROPOSALS RELATED TO THE FINANCE OF PROJECTS FOR THE MOST REPRESENTATIVE PROJECT MANAGEMENT STANDARDS >



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ABSTRACT

The search and selection of the financing line for a project is one of the first decisions to be made in order to be able to carry out the desired project and thus meet the profit objectives set. This decision is not always taken by the project manager, but without a correct study of the project economics needs it is impossible to make the right decision on which financing to choose.

Therefore, the existing project management standards include the knowledge, processes, techniques, and tools for a project manager to successfully manage any type of project throughout its entire life cycle, in which financing is present from the planning stages through initiation, execution and control to closure. The decision-making phase is the planning phase, where the investment project and the business plan, key documents for a good choice, are presented.

This research aims to collect the information available today in some of the most representative standards, as well as to make a comparison between them afterwards. Finally, new methodologies will be proposed as well as best practices, tools and techniques complementing the existing ones.

The process followed is as follows: First a study of the standards PMBOK Guide Seventh Edition, IPMA ICB 4.0, PM2 guide, ISO 21500:2012 y PRINCE 2 training manual is made. Information related to project finance is collected for each of them.

Subsequently, the standards are compared with each other. After this comparison, the methodology followed in the standard for construction Construction Extension to the PMBOK Guide is described, and a review of the state of the art is also made by searching scientific articles as well as information from specialized journals.

Finally, a new methodology is proposed with some steps to follow as well as good practices.

Key words: finance of projects, project cost estimation, financial risk management, project benefit management, project investment appraisal

RESUMEN

La búsqueda y selección de la línea de financiación de un proyecto es una de las primeras decisiones que se han de tomar para poder llevar adelante el proyecto deseado y cumplir así con los objetivos de beneficio marcados. Esta decisión no siempre es tomada por el gestor del proyecto, si bien sin un correcto estudio de las necesidades económicas del proyecto es imposible poder tomar la decisión correcta de qué financiación elegir.

Así pues, los estándares de gestión de proyectos existentes recogen el conocimiento, los procesos, las técnicas y las herramientas para que un gestor de proyecto pueda llevar a cabo la gestión de cualquier tipo de proyecto con éxito a lo largo de todo su ciclo de vida. Durante ese ciclo la financiación está presente desde las fases de planificación hasta el cierre, pasando por la iniciación, ejecución y control. La fase en la que se toma la decisión es la de planificación, que es donde se presentan el proyecto de inversión y el plan de negocio; documentos claves para una buena elección.

Este trabajo pretende recoger la información disponible hoy en día en algunos de los más representativos estándares y hacer una comparación entre ellos posteriormente. Finalmente, se propondrán nuevas metodologías a seguir, así como buenas prácticas, herramientas y técnicas complementando las ya existentes.

El proceso seguido para ello es el siguiente: Primero se hace un estudio de los estándares PMBOK Guide Seventh Edition, IPMA ICB 4.0, PM2 guide, ISO 21500:2012 y PRINCE 2 training manual. La información relacionada con la financiación de proyectos es recopilada para cada uno de ellos.

Posteriormente, los estándares son comparados entre ellos. Tras esta comparación, se describe la metodología seguida en el estándar para construcción Construction Extension to the PMBOK y también se hace una revisión del estado del arte mediante la búsqueda de artículos científicos, así como de información de revistas especializadas. Finalmente, se propone una nueva metodología con unos pasos a seguir, y también buenas prácticas.

Palabras clave: financiación de proyectos, estimación de costes de proyectos, gestión de riesgos financieros, gestión de beneficios de proyectos, evaluación de inversión de proyectos

LABURPENA

Proiektu baten finantzaketa lerroaren bilaketa eta aukera nahi den proiektua aurrera eramateko eta honen irabazien helburuak betetzeko hartu behar den lehenengo erabakietakoa da. Erabaki hori ez du beti proiektuaren zuzendariak hartuko, nahiz eta finantzaketa aukera egokia hartzea guztiz ezinezkoa den ez badira behar bezala ezagutzen proiektuaren beharrian ekonomikoak.

Hala, proiektuen kudeaketaren estandarrek proiektu-zuzendariak bere bizitzan zehar edozein motatako proiektuen kudeaketa arrakastaz aurrera eramateko ezagutzak, prozesuak, teknikak eta erramintak jasotzen dituzte. Proiektuaren bizitza ziklo osoan zehar proiektuaren finantzaketa dago, plangintza fasetik itxierara arte; hasiera, gauzatze eta egiaztapen faseetatik igarotzen da. Aukera plangintza fasean egiten da; bertan inbertsio proiektua eta negozio plana aurkezten dira eta dokumentu horiek aukera egokia hartzeko gakoak dira.

Ikerketa hau gaur egungo estandar garrantzitsuenetan eskura dagoen informazioa biltzen saiatzen da, eta euren artean konparaketa bat egiten ere. Amaitzeko, metodologia berriak proposatuko dira baita jardunbide egokiak, erramintak eta teknika berriak ere, horrela gaur egungoak osatuko dira.

Jarraitutako prozesua honako hau da: lehenik eta behin, PMBOK Guide Seventh Edition, IPMA ICB 4.0, PM2 guide, ISO 21500:2012 eta PRINCE 2 training manual estandarrak aztertzen dira. Bakoitzean proiektu finantzaketari buruz aurkitutako informazioa biltzen da.

Ondoren, estandarren arteko konparaketa egiten da. Konparaketa horren ostean Construction Extension to the PMBOK Guide proiektu finantzaketarako jarraitutako metodologia deskribatzen da, baita gaur egungo egoeraren berrikuspena eginez ere artikulu zientifikoak eta aldizkari espezializatuak aztertuko dira.

Amaitzeko, metodologia berria proposatzen da jarraitu beharreko pausuekin eta jardunbide egokiekin.

Hitz gakoak: proiektuen finantzaketa, proiektuen kostuen zenbatespena, arrisku finantzarioen kudeaketa, proiektuen irabazien kudeaketa, proiektuen inbertsioaren ebaluazioa

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List of acronyms

A.....	Accountable
AGB.....	Appropriate governance body
ANN.....	Artificial Neural Network
APMA	Association for Project Management
BIM	Building information modelling
BM	Business manager
BOT	Build-Operate-Transfer
BT	Bow-tie model
C.....	Consulted
CBS	Cost Breakdown Structure
CSF	Critical success factors
CSV	Comma separated values
C&S	Consequences and sequels
DOAJ.....	Directory of Open Access Journals
DSS	Decision support systems
EMT.....	End Master Thesis
ETA	Even tree analysis
EVM.....	Expected money value
FST.....	Fuzzy set theory
FTA.....	Fault tree analysis
FSB	Fuzzy rule based
FSE	Fuzzy synthetic evaluation
FUV	Fuzzy utility value
GA	Genetic algorithm
GCGS.....	Green credit guarantee scheme
HS	Harmony Search
I	Informed
ICB	Individual Competence Baseline
IPMA.....	International Project Management Association
ISO	International standard organization
KPI.....	Key performance indicator
MCDM	Multiple criteria decision making
PESTEL.....	Political, economical, social, technological, environmental, and legal
P-I.....	Project-Impact
PIR	Project initiating request
PMB.....	Project management board

PMBOK.....	Project Management Body of Knowledge
PM	Project Management
PMI	Project Management Institute
PO	Product owner
PPP	Private public partnership
PRINCE	Projects in Control Environments
PSC	Public sector comparator
PSC	Project Steering Committee
R.....	Responsible
RAM	Responsibility assignment matrix
RE	Renewable energy
RIS	Research information system
S.....	Supports
SMA.....	Science mapping analysis
SP.....	Solution provider
SWO.....	Statement of work
TFM	Trabajo de Fin de Máster
WBS	Work Breakdown Structure
WoS.....	Web of Science

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1 Introduction

1.1 Project finance vs financing of project and its importance

Every organization requires capital to run its daily operations, and the initial capital of a firm can never be sufficient for the proper running of the business. The financial needs and different sources from where funds can be arranged have to be identified and estimated because a business can run its operations effectively and efficiently, but that means having the adequate funds and making the best use of them (*Factors Affecting the Choice of the Source of Funds - GeeksforGeeks, s. f.*).

Looking for the meaning of “finance” in the dictionary, many different definitions can be found. The next three definitions are supposed to be for business English taken from the Cambridge dictionary (*FINANCE | English meaning - Cambridge Dictionary, s. f.*).

- Money borrowed from an investor, bank, organization, etc. in order to pay for something (also known as financing).
- The activity or business of managing money, especially for a company or government.
- The study of the way money is used and managed in the economy.

Furthermore, definitions for “business finance” can also be found (*FINANCE | English meaning - Cambridge Dictionary, s. f.*).

- Money that is lent to a business by a bank or other financial organization.
- The activity of lending money to businesses.

Looking deeper, a more into business definition of financing, stands for the process of funding business activities, making purchases, or investments. Financial institutions, such as banks, are in the business of providing capital to businesses, consumers, and investors to help them achieve their goals. The use of financing is vital in any economic system, as it allows companies to purchase products out of their immediate reach. (*Financing: What It Means and Why It Matters, s. f.*).

All the definitions presented refer to the quantity of money coming from a source and the way it is used by the one receiving it. This could lead to the already known knowledge area for some business activities named as “Financial management”.

Financial Management means planning, organizing, directing, and controlling the financial activities such as procurement and utilization of funds of the enterprise. It means applying general management principles to financial resources of the enterprise (*Financial Management - Meaning, Scope, Objectives & Functions, s. f.*).

Good financial management of the economic resources of a company is of prominent importance. In fact, finance is so indispensable today that it is rightly said to be the blood of an enterprise. Without adequate finance, no enterprise can possibly accomplish its objectives (*Pandey, s. f.*).

In fact, the research done through 111 postmortem companies from all around the world from 2018 until present day by CBI Insights, found out that the main reason for startups fails, small businesses highly dependent on a successful financing strategy, was the ran

out of cash or the failure of raising new capital. Money and time are finite and need to be allocated judiciously. Therefore, it shall be identified and estimated the financial needs and different sources from where funds can be arranged.

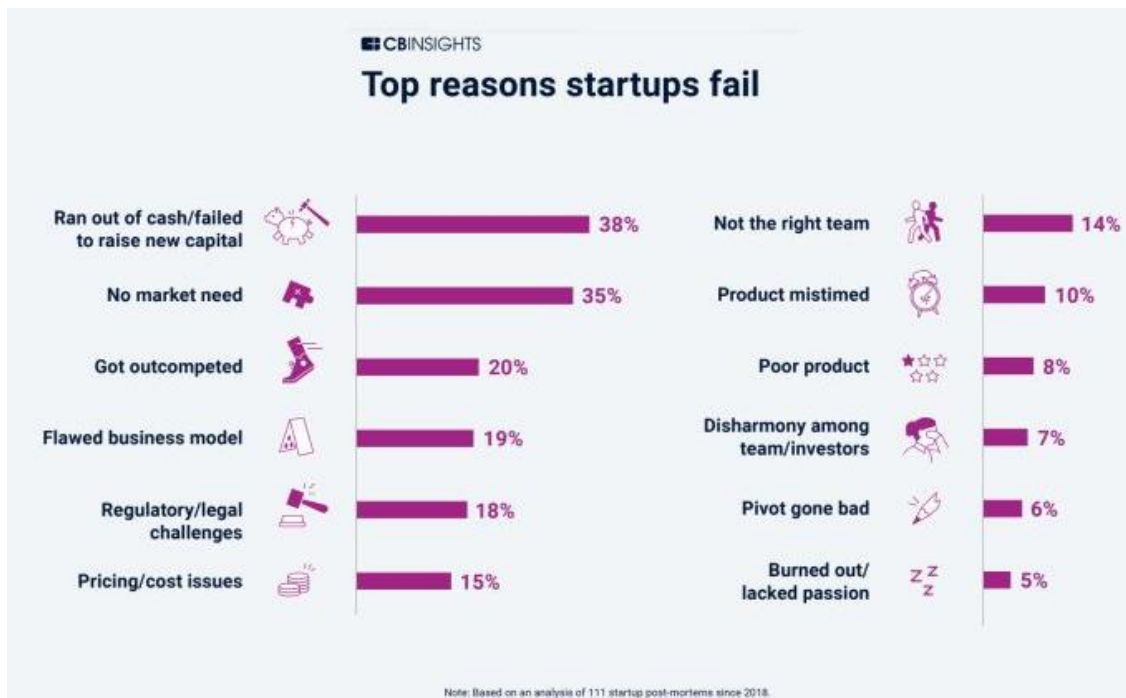


Figure 1 – 12 reasons for startups failure (Source: CBInsights)

Seen from a more theoretical point of view, the financial planning is beneficial in terms of the following points (*Importance or Benefits of Financial Planning, s. f.*).

1. Forecast of cash flows
2. Raising finances
3. Managing the flow of internal funds
4. Facilitate cost control
5. Facilitate pricing of product
6. Forecasting profits
7. Measuring required returns
8. Managing assets
9. Managing funds
10. Managing Cost
11. Miscellaneous importance

Projects cannot be treated any differently in the field of financing. When looking for information about the project finance or finance of the project, it seems that it is not relevant to use any of these expressions. The truth is that they apparently look just the same, but both expressions do not refer to the same type of funding exactly. It is attending to the purpose and period of the project where the differences can be found.

There is a type of funding resource used for long-term projects called “Project Finance”. It can be defined as the funding or financing of long-term infrastructure, industrial projects, and public services using a non-recourse or limited recourse financial structure. The debt and equity used to finance the project are paid back from the cash flow

generated by the project (Pinto, 2009). On the other hand, project funding is defined as the means by which the money required to undertake a project, programme or portfolio is secured and then made available as required. Funding for standalone projects may be via a single source or through multiple investors.

When trying to find information about funding sources that are not a “Project finance”, that means using finance of projects expression, and the data available is largely shorter than the data available for the “Project finance” structure. This work is focused on the process of choosing the best finance for a project.

1.2 Financial management for financing success and the project manager role

There is a wide variety of funding sources available from which the projects can be financed. Starting from the top level, the internal (sources of finance that refer to money that comes from within a business) and external (sources of finance that refer to money that comes from outside a business) sources, that can be further divided into owners’ capital, retained profit, and selling assets for the internal, and own and outside for the external.



Figure 2 – Funding sources (Source: stakeholdermap.com)

The sources are chosen based on the documents project charter and business case. As described within (Pinto, 2009), the project statement of work addresses the business

need, the product scope description, and the organization strategic plan (especially the way that the project helps fulfill the strategic vision). The business case provides the necessary information that is needed from a business standpoint. It is a consequence of (or a combination of) a market demand, an organizational need, a customer request, a technological advance, a legal requirement, an ecological impact, or a social need. Typically, it includes the business need and the cost-benefit analysis.

It can also be said that there are some factors that affect the choice of the source, and are as follows (*Factors Affecting the Choice of the Source of Funds - GeeksforGeeks, s. f.*):

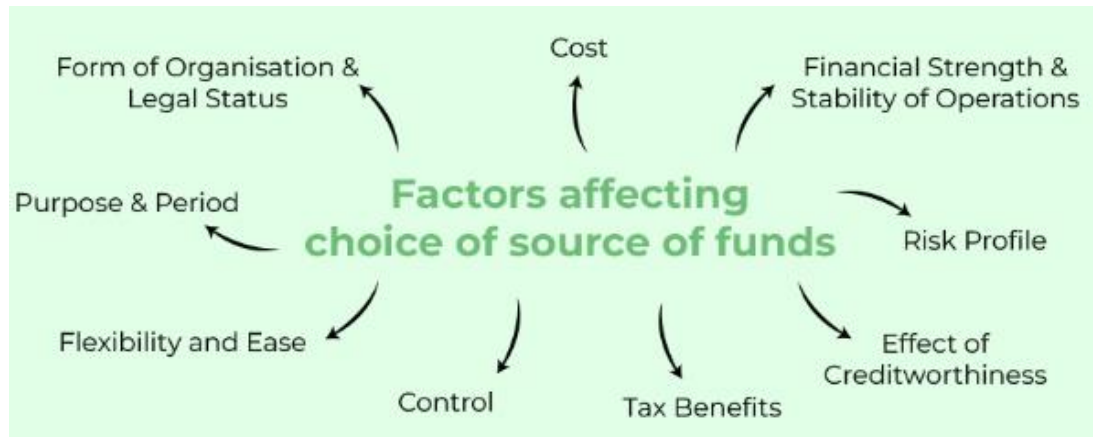


Figure 3 - Funding decisions factors (Source: www.geeksforgeeks.org)

1. Cost
2. Financial strength and stability of operations
3. Risk profile
4. Effect of creditworthiness
5. Tax benefits
6. Control
7. Flexibility and ease
8. Purpose and period
9. Form of organization and legal status

The role of a project manager in the field of financial management within a project is not always treated the same way. As stated in (Pinto, 2009), the financing area of the project is, in the case of many projects, considered to be within the stakeholder area of influence and, because of that, is not directly addressed by the project manager. But without project management tools and techniques and without correctly studying the cost of the project, it's impossible to know exactly the amount of money that the project needs and the cost baseline that influences the finance need of the project.

Many statements of what a project manager is responsible for can be found in many different sources, but for example, in the definition found in the APMA, it says that "the project manager is responsible for day-to-day management of the project and must be competent in managing the six aspects of a project:

1. Scope,
2. Schedule,

3. Finance,
4. Risk,
5. Quality
6. Resources.

Project managers work on specific projects that have definite outcomes, have time limits, and have to stay within a budget (*What Does A Project Manager Do? | Role & Responsibilities | APM, s. f.*).

This means that the approach done in many projects with the project manager not directly addressing the financial management is not the most correct one since one of the responsibilities of a project manager is supposed to be the finance. (Turner, 2006) identifies through several project management standards 17 inherit components of project managements, being the component 3 the financial management.

This leads to the fact that the standards for project management should be gathering the needed information for that area. A standard is a document, established by consensus and approved by a recognized body, which provides for common and repeated use, rules, guidelines or characteristics for activities or their results, aimed at the achievement of the optimum degree of order in a given context (*About Standards | PMI, s. f.*).

The standards covered through this document will be:

- PMBOK Guide Seventh Edition
- IPMA ICB 4.0
- PM2 guide
- ISO 21500:2012
- PRINCE2 training manual

They are the most relevant ones in the project management field nowadays. It will also be included the Construction extension to the PMBOK guide due to the fact that it includes Financial Management for the construction industry.

2 Context

As quoted in (Pinto, 2009) with small and minor adjustments, the Construction Extension to the PMBOK® Guide Edition (PMI, 2016) could be considered for most projects, since it provides an excellent starting point for the questions that we have when we try to make the mind set change from cost to finance.

Because the financial management knowledge is not an area treated just in some industries, but affects all types of projects, the standards for the project management should cover the financial management area of knowledge, or at list, provide project managers with the tools, techniques, or best practices.

(Martins, 2017) pointed out that in spite of the large amount of work relating project scheduling and cash-flows, less attention has been given to borrowing strategies for supporting projects' costs. In many practical problems, loaning is not a choice but the unique option for initiating the process. In fact, an adequate loaning strategy is crucial, not just for launching the project but also for guaranteeing its financial success.

In this sense, the "Treatment, comparison and new processes proposal related to the finance of projects for the most representative project management standards" document aims to study how the mentioned most relevant standards do that covering and if the project managers are properly guided not only through the cost management or budget definition in example, well known covered within the standards, but also through whole the financing area.

In the field many studies have been carried out and much information about the different available sources so as its managing through the time has been written. This information can be found within many articles, books, journals, magazines, etc., but clear steps to be followed should be given to the project managers.



Figure 4 – Financial planning flow chart (Source: wikifinancepedia.com)

Figure 4 describes an example providing steps for the financial planning and controlling stages (Team, 2018). (Pandey, s. f.) defines the meaning of financial management as that part of the management activity, which is concerned with the planning and controlling of firm's financial resources. It deals with finding out various sources for raising funds for the firm. (Pandey, s. f.) also gives the functions for the financial manager, which can also be understood as the steps to be followed for a financial management:

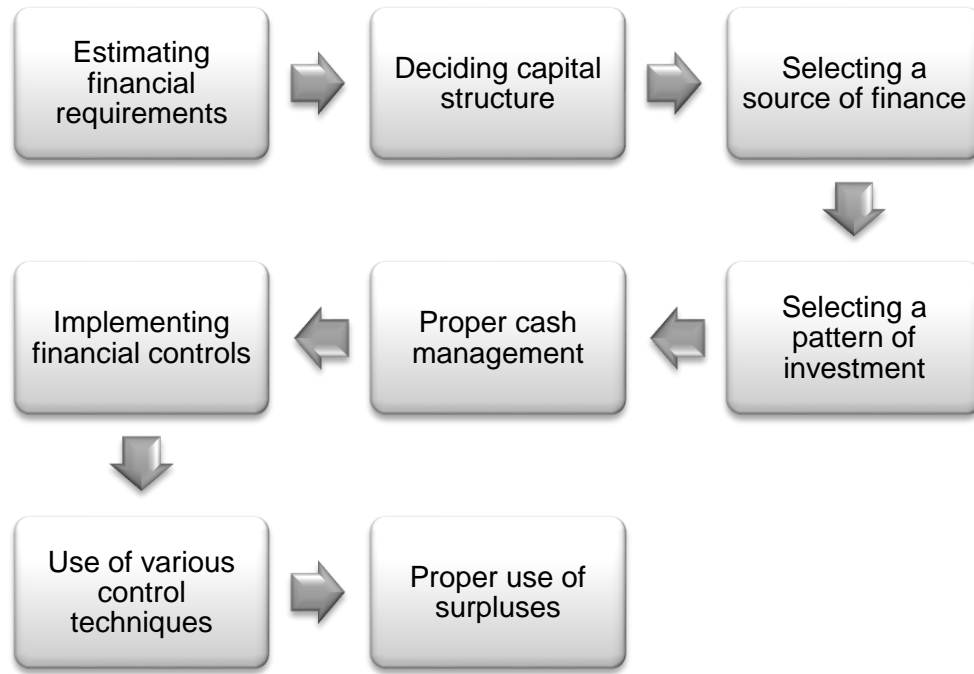


Figure 5 – Functions of financial management (Source: Pandey, Financial Management)

Types of financial sources and characteristics, businesses capital structure definitions and analysis of it, or definition of budget and evaluation of costs are easy finding through many different literatures with great similarities between them. This study aims to complement all that information with the process for the project managers at the field of the financial management, accompanied by the tools, techniques, or best practices for the area.

3 Scope

The scope of this work is to study, describe and compare the existing processes, tools, techniques, and best practices through the PMBOK Guide Seventh Edition, IPMA ICB 4.0, PM2 guide, ISO 21500:2012 and PRINCE 2 training manual standards related to the financing of the projects for the project manager role, as well as propose needed new processes, tools, techniques, and best practices to complement them.

To support the aim of the document, the Finance of projects for construction projects. Construction Extension to the PMBOK® Guide Edition (PMI, 2016) standard is added into this work. The scope of doing it is to describe the process for the funding of this kind of projects since those are huge projects usually with a difficult financial management to be done by the project manager and whose decisions at this field are part of the key for a successful project.

It can be said that three are the main purposes to be achieved from conducting the study in terms of financing for projects to what it is expected from a project manager role:

1. Study the state of the art of the financing within the most relevant standards for project management.
2. Review the bibliometric data related to finance of projects that researchers provided through the last decade (2012-2022).
3. Propose, if needed, new processes for financing for the project management.

Through the guidelines or standards, many processes and procedures could be found, but even though both terms seem to describe the exact, they do not have the same meaning. In every work to be done, three main questions arise:

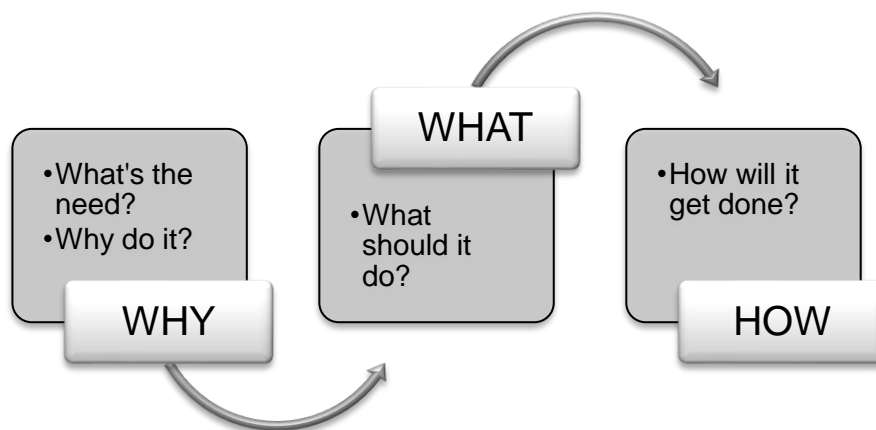


Figure 6 – Why, what, and how (Source: why-what-how.com/)

The Why questions are mainly answered being the project necessity the answer to it. Understand why you need funding and define the needs.

The next question would be What, which could be answered with a process. A process is a series of steps and decisions involved in the way work is completed. (*What is a Process? • ProcessModel, s. f.*), it describes inputs, outputs, and deliverables. This is what can be called also designing a solution.

On the other hand, a procedure is a prescribed way of undertaking a process or part of a process, it describes how to use the inputs to produce the expected outcomes. This means that the How question would be answered with a procedure. Implementing the solution, developing, and deploying, measuring, monitoring, and learning

The aim of this work is not to describe how the management needs to be done specifically step by step, just focusing on the process as described. Inputs and outputs will be provided for the process, as well as a brief definition and content of each output. They will not be further developed anyway.

This work is not a new topic on the project management role, so it doesn't attempt to discover new ways of carrying out the funding of the project but just to gathering the exiting one and complementing it with interesting practices found through bibliographic reviews.

4 Literature review

4.1 Finance of projects within project management standards. A comparison between them.

In order to develop a framework for the study of the funding of projects it is helpful to begin by considering the reference standards within the Project Management discipline. The construction extension to the PMBOK Guide Edition (*PMI, 2016*) is also included studying the financial management area following the stated in (*Pinto, 2009*).

4.1.1 PMBOK Guide Seventh Edition

The PMBOK-Guide-Seventh Edition as quoted in (*PMBOK® Guide Seventh Ed, 2021*), is a principle-based standard to support effective project management and to focus more on intended outcomes rather than deliverables. It also provides a systems view of project management, what is reflected in eight performance domains, defined as a group of related activities, Figure 51. Previous to describing the principles or the domains, in the (*PMBOK® Guide Seventh Ed, 2021*), The Standard for Project Management defines the Project Manager (PM) as the person assigned by the performing organization to lead the project team that is responsible for achieving the project objectives. Several functions are associated to its role and presented in the standard, even though it is pointed out that these could not be the only ones, being the functions dependent on the needs of the project, organization, and environment.

Many tasks are assigned to the PM within the eight functions described in the PMBOK Guide Seventh Edition related to projects for a value delivery system. The standard covers those functions throughout the whole project life cycle, starting from orchestrating, that means planning, continuing with monitoring, and ending with controlling activities. It specifically depends on the organization, but it can also include some pre-project activities such as evaluation and analysis. Within this function, coordination can mean assisting business analysis, tendering and contract negotiation, and business case development, while oversight involves follow-on activities regarding the benefits realization and sustainment after the project deliverables ending, before closure. Following the life cycle of the project, most of the functions are more related with supporting, advising, and directing the day-to-day activities and people conforming the team as well as the external stakeholders. In this way, the costumer (differentiating it from the end user), is understood as the individual or group requesting or funding the project, first time the standard mentions the funding, even though, the function regarding the customer is more related to the feedback process from both sides.

It is not until the "Provide business direction and insight" function, that PMBOK Guide Seventh Edition finds that in some instances the business direction can interact with funding and resourcing functions. Besides, within the mentioned function, the supporting role to be fulfilled in this field is supposed to provide an escalation path for problems, issues, or risks, such as shortage of funding or other resources. In this function, outcomes after closure can also be monitored to ensure intended business benefits. The standard finds out the funding to be part of the functions of the project management even though it is referred to in the latter stages than in the planning of the financing, in which the first decisions towards it, that will be decisive, are taken.

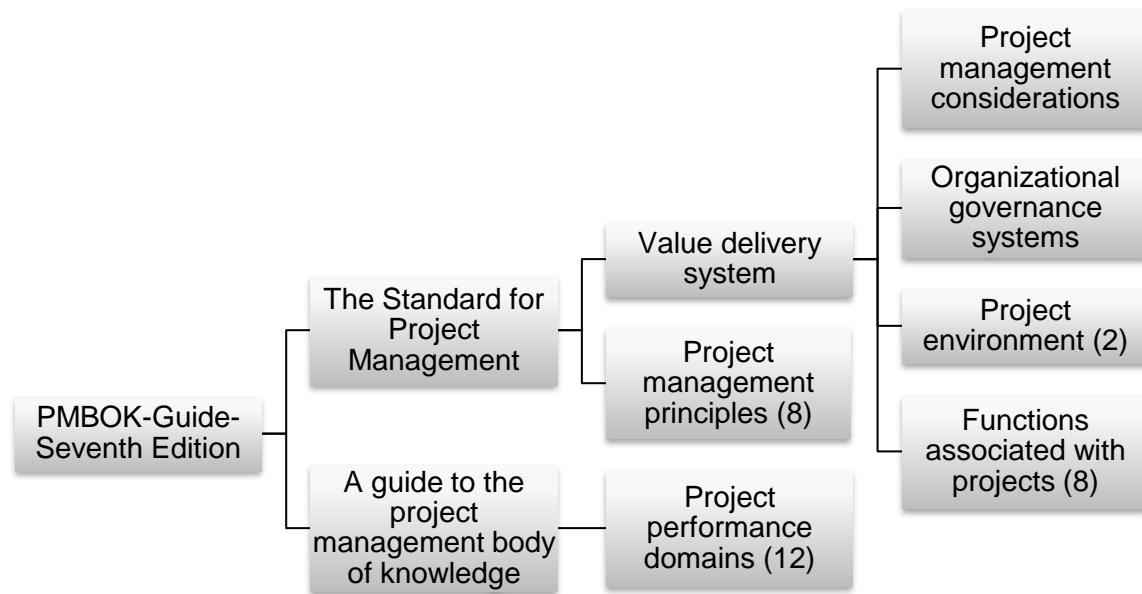


Figure 7 – Structure of the PMBOK Guide Seventh edition

Among the factors influencing the project two main groups can be found, the internal and external. PMBOK Guide Seventh Edition describes some examples for both cases, finding inside the external factors two related with the finance of projects, the commercial databases containing cost estimating data and the financial considerations including currency exchange rates, interest rates, inflation, taxes, and tariffs (*PMBOK® Guide Seventh Ed, 2021*).

The principles stated in The Standard for Project Management within the PMBOK Guide Seventh Edition are 12 of them. They are supposed to serve as foundational guidelines for strategy, decision making, and problem solving, as they are intended to guide the behavior of people involved in projects. Within “Be a diligent, respectful, and caring steward” principal, finance is mentioned from a point of view in which the steward takes care of the organizational finances along with materials or other type of resources used within a project being this a responsibility within the organization and not external to it. The Standard for Project Management states that “Increasingly, organizations are taking a holistic view to business that considers financial technical, social, and environmental performance simultaneously instead of sequentially.” (*PMBOK® Guide Seventh Ed, 2021*).

It is not until the “Focus on Value” principle that a document in which the funding needs are defined for project is mentioned again. However, before “Focus on value”, cost is included within “Effectively engage with stakeholders” principle as they do affect this aspect of the project regardless being either internal or external stakeholders. Cost is one of the main inputs for funding choices. Other important aspect of a project that are closely related to the funding are the benefits, also mentioned by this principle related to the stakeholders as they do affect them for good or for bad, in addition to risk and success.

As The Standard for Project Management says, if not all, many projects are initiated on a business case, containing this document information about strategic alignment,

assessment of risk exposure, economic feasibility study, return on investments, expected key performance measures, evaluations, and alternative approaches. The intended value may be stated in the document, including the business needs, which are the goals and objectives; the project justification accompanied by a cost benefit analysis consequently addressing why the investment is worth it; and finally, the business strategy, the reason and needs for the project and the strategy to achieve the value (*PMBOK® Guide Seventh Ed, 2021*).

Within The Standard for Project Management some principles referring to changes and their effects for project aspects are mentioned, within which costs and funding are included. A project is seen as a system within the “Recognize, evaluate, and respond to system interactions” principle, referring to the funding as an example of a situation within a construction project in which a change in requirements can lead to changes on project cost, schedule, scope, and performance subsequently affecting providers, regulators, financiers, and government authorities. The changes in projects can affect the finance of a projects. “Demonstrate leadership behavior” includes seeking resources and support for the project too along with some more skills. “Navigate complexity” principle also refers to the complexity that can appear within a project impacting in any area and at any point in project life cycle due to different sources, what means that finance can also be affected. Moreover, “Optimize risk responses” adds responses to risks to be cost effective. Threats may include cost overrun, while opportunities may lead to cost reductions. A risk threshold and a risk appetite can also be added to the cost objectives depending on the organization and stakeholders.

As for the resources, tailoring, principle “Tailor based on context”, The Standard for Project Management, enables to efficiently plan the project adjusting the cost of the processes, this also means an efficient use of the resources. The “Build quality into processes and deliverables” (*PMBOK® Guide Seventh Ed, 2021*) principle also helps to enhanced cost control by using quality management processes and practices within a project. The principles studied in The Standard for Project Management so far are related to the performance domains described within the PMBOK guide in the way that the principles to guide behavior while the performance domains present broad areas of focus in which to demonstrate that behavior (*PMBOK® Guide Seventh Ed, 2021*).

There are 8 project performance domains mentioned in A guide to the project management body of knowledge. At first glance, any of the domains seems to focus on the definition and choice of the finance for a project, if not included within the “Development Approach and Life Cycle” or “Planning”. Nevertheless, the domains are interactive, interrelated, and interdependent areas.

“Development Approach and Life Cycle” performance domain refers to the funding availability as a variable belonging to the project category for choosing a development approach. Not only the approach is dependent on funding availability, but the decisions towards the product and the investment are too. The initial phase of start up for aligning the delivery cadence, development, approach, and life cycle points out that based on the business case, some decisions are made, being one of them the establishing the initial funding requirements.

Some more information regarding costs is provided within the “Planning” performance domain. Cost is closely linked to funding, and on the planning phase of a project an estimation of it is done. In this sense, A guide to the project management body of knowledge describes to estimate as “A quantitative assessment of the likely amount or outcome of a variable, such as project costs, resources, effort, or durations.” Besides, another very close term to funding, budget, is defined as “The approved estimate for the project or any work breakdown structure (WBS) component or any schedule activity.” Within these definitions, crashing, that is a way of scheduling a project, is added as “A method used to shorten the schedule duration for the least incremental cost by adding resources.” (*PMBOK® Guide Seventh Ed, 2021*). No direct mention of funding is made anyway.

Depending on the phase in which the life cycle of the project is, 4 aspects associated with estimating are impacted. These are range, accuracy, precision, and confidence. They vary from higher to lower values impacting the estimation value done. Furthermore, closely related to these aspects, four ways of presenting and/or adjusting estimates are provided within A guide to the project management body of knowledge. Deterministic and probabilistic estimating, absolute and relative estimating, flow-based estimating and adjusting estimates for uncertainty. The budget is related to funding in the way that the funds available will be limiting the budget for the project and when the money will be spent, taking also into consideration that contingency funds allowing for uncertainty need to be added. Within another domain, that is “Project work performance domain”, the question “Where is the next best funding spent?” is answered, what helps the project team evaluate the tasks to optimize value delivery. The funding is finally mentioned in this domain as referring to it within the holistic manner in which the project should be planned, being funding one of those aspects included that if followed the view, demonstrate no gaps or misalignment. The funding is, therefore, present and alive within domains that are supposed to reflect ongoing projects activities, most of the presence being to adapt to the costs or budget to changes within the life cycle of the project, what can affect initial funding planning.

The so-called project-authorizing documents are mentioned in “Delivery performance domain”, which are the basis for the realization of the project, hence for the funding. The business case document can be written in many formats depending on the development approach and life cycle selected, but all those varieties contain references to investments and returns or costs structures, are inputs for funding selection. They also contain the information to confirm that the project benefits are being accomplished within the time frame for which they were planned. These documents attempt to quantify the project’s desired outcomes to allow for periodic measurement. The definition of the requirements and the managing of these also lead to budget changing, costs overruns, etc., depending them to a large extent on the life cycle stage of the project.

Within the “Measurement performance domain”, A guide to the project management body of knowledge, includes the cost along with the scope in the baseline performance category as a baseline for measuring the ongoing of the project through 3 different indicators, actual cost compared to planned cost (AC), cost variance (CV) and cost performance index (CPI). Some more indicators inside the business value category related to financial aspects of the project are shown for different measurements, which are cost-benefit ratio, planned benefits delivery compared to actual benefits delivery,

return on investment (ROI) and net present value (NPV). Finally, funding is mentioned within the last domain, “Uncertainty performance domain” referring to it as an aspect that contributes to the project uncertainty, the ability to borrow funds.

Two models, thinking strategies, are presented for the planning, which point out that there must be a balance for the time spent in this planning stage to be it more effective. It is stated that “By taking more time to plan up front, many projects can reduce uncertainty, oversights, and rework” (*PMBOK® Guide Seventh Ed, 2021*). However, “the longer the time spent planning, the longer it takes to get a return on investment, the more market share could be lost, and the more circumstances can change by the time the output is delivered.” A guide to the project management body of knowledge (*PMBOK® Guide Seventh Ed, 2021*).

As for the methods, what is the means for achieving an outcome, output, result, or project deliverable, inside the “Data gathering and analysis” group, a Business Justification method is presented. The next parameters are to be calculated so that the project or a decision is authorized or justified; payback period, internal rate of return (IRR), return on investment (ROI), net present value (NPV) and cost-benefit analysis.

The Expected monetary value (EMV) method expresses the estimated value of an outcome in monetary terms, which along with the Forecasting, helps for financial analysis. Some more methods that would help in the funding decisions with regards to risk and probabilities are probability and impact matrix, regression analysis, reserve analysis, sensitivity analysis, simulations, SWOT analysis, trend analysis and What-if scenario analysis. 9 methods for estimating or developing an approximation of work, time or cost on a project are described in A guide to the project management body of knowledge (*PMBOK® Guide Seventh Ed, 2021*), which are, affinity grouping, analogous estimating, function point, multipoint estimating, parametric estimating, relative estimating, single point estimating, story point estimating and wideband Delphi.

To finish, A guide to the project management body of knowledge (*PMBOK® Guide Seventh Ed, 2021*) provides artifacts that are templates to follow. Within them a business case and a project charter can be found, the so-called project-authorizing documents mentioned before. A cost management plan and a budget template are also included.

4.1.2 IPMA ICB 4.0

The IPMA ICB 4.0, as stated by (*IPMA ICB4, 2015*), is a global standard that defines the competences required by individuals working in the field of projects, program and portfolio management, even though for this document the project management domain will be the only one under study. The IPMA ICB 4.0 describes individuals who work in this domain, while avoiding role-specific terminology because although a role name may change, the underlying concept remains valid. Three competence areas or domains are defined to provide a complete inventory of competences, which are people, practice, and perspective. The standard is not a ‘how to’ guide or a cookbook for managing projects, it does not describe the processes or steps involved. However, it can be used alongside other global process-oriented standards.

It is within the explanation of the structure of the standard that the IPMA ICB 4.0 mentions for the first time the funding. Inside the competences defined for the practice domain, the

first competence Design (Practice 1), is explained as the ‘charcoal sketch’ that defines the high-level choices for the project, giving some examples among which, the funding is located; make or buy, linear or iterative, possible funding or resourcing options, and how to manage the project. These choices are also visible in the other technical competence elements, where each of them will be specified, implemented, and managed. It also says that projects are dependent on the input of people, material, and money. For this reason, a Finance (Practice 7) competence is specified within the standard. The rest of the practice domain competences are also related to the finance due to that all the competences within practice are related between them, as exposed by IPMA ICB 4.0, Table 1.

Practice area or domain
Project design (Practice 1)
Requirements and objectives (Practice 2)
Scope (Practice 3)
Time (Practice 4)
Organization and information (Practice 5)
Finance (Practice 7)
Quality (Practice 6)
Resources (Practice 8)
Procurement (Practice 9)
Plan and control (Practice 10)
Risk and opportunity (Practice 11)
Stakeholders (Practice 12)
Change and transformation (Practice 13)

Table 1 – Practice domain competences (Source: IPMA ICB4)

IPMA ICB 4.0 expresses that the “Design describes how the demands, wishes and influences of the organization(s) are interpreted and weighed by the individual and translated into a high-level design of the project to ensure the highest probability of success.” (IPMA ICB4, 2015). The sketch of the project design is not only based on the funds for what the money is referred, but also in the benefits, risks, and opportunities, which do affect at a high level the success of the project. These aspects do appear within the key competence indicators for the design of a project, Figure 8.

Being the purpose of the Requirements and objectives (Practice 2) competence element to enable the individual to establish the relationship between what stakeholders want to achieve and what the project is going to accomplish (IPMA ICB4, 2015), the benefits mapping, closely related to the finance decisions, is among the knowledge. The budget is an input for the definition and development of the project goal hierarchy key competence indicator.

The benefits are included within the Scope (Practice 3). In the definition of the work packages in the work breakdown structure (WBS), the costs are included in each of them. Those costs are also used to monitor the progress with methods such as earned value (EV).

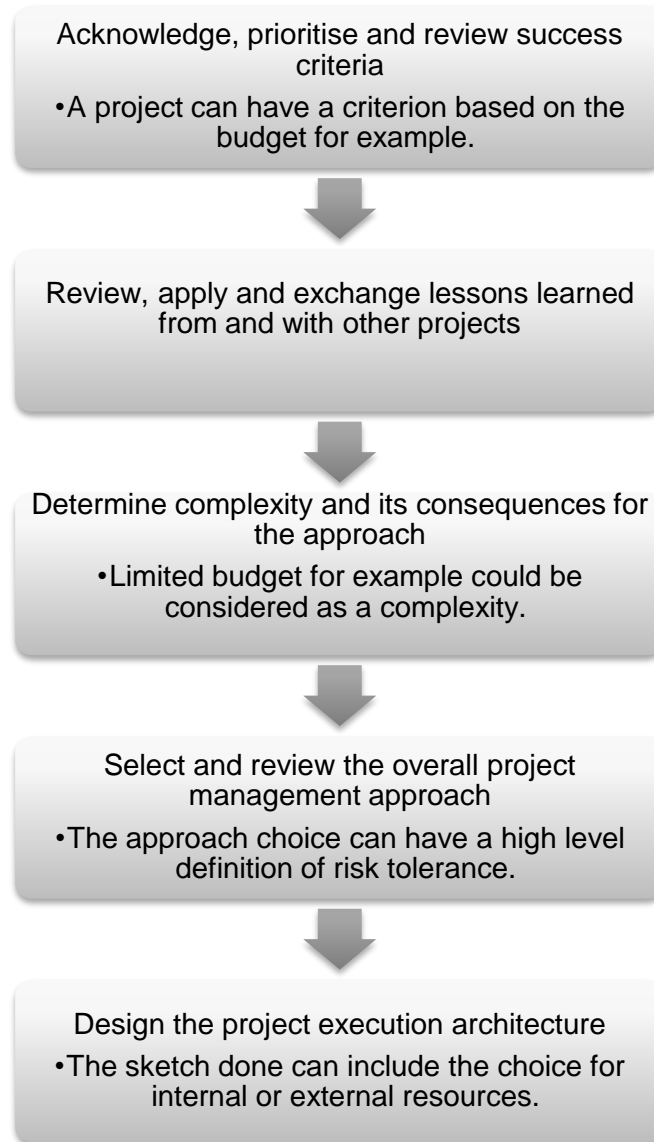


Figure 8 – Design (Practice 1) key competence indicators (Source: IPMA ICB4)

IPMA ICB 4.0 defines that “Finance includes all activities required for estimating, planning, gaining, spending and controlling financial resources, both the inflow and outflow to the project” (IPMA ICB4, 2015). Finance, therefore, includes the cost management (outflow often related to a budget) as well as the financing (inflow external to the organization) and/or funding (inflow from within the organization) required for successful management of the project.

The standard provides the individual with guides for developing the finance of a project, starting with an estimation of the needed economical resources for the project, or also called estimation of costs, such as a budget. The budget estimation is closely related to the cost estimation. The planned and actual costs are to be followed as well as the relation of these costs to the progress of the work done and the objectives achieved through a cost breakdown structure (CBS), which can be derived from a work breakdown structure (WBS).

The budget, based on the cost estimation, is properly allocated through the tasks. These costs need to be monitored through proper cost management systems. The individual should know what funding is contracted and what funding is expected, so that key performance indicators are used for forecasting the project ongoing. When costs breaches are found, mitigation plans need to be suggested, also included in the budget estimation as contingencies (held in reserve to fund uncertainties, risks, claims or cost overruns) after reporting these breaches to the project's organization and governance. Careful needs to be taken when talking about funding or finance as IPMA ICB 4.0 differentiates both terms such as (IPMA ICB4, 2015):

- Funding: The organization finances the project internally.
- Finance: The organization finances the project externally.

For estimating the costs, all types of costs that can be identified need to be addressed, setting up in this way the cost structures and cost categories. This estimation could be carried out following a CBS. IPMA ICB 4.0 describes two different methods for doing calculations such as cost estimation, cost targets for the whole project or single cost categories, which could also be supported by cost standards or normative that help with techniques (IPMA ICB4, 2015):

1. Top-down calculation.
2. Bottom-up calculation.

The standard also mentions the cash flow. It finds that these flows and the management of them are relevant in terms of expenditure and income (IPMA ICB4, 2015). The flows can be inflow or outflow, but both need to be calculated and then controlled regularly. In this way actions can be taken to ensure sufficient financial resources. All the required management and the planification regarding it must be done in cooperation with the financial and/or treasury department and other relevant parts of the permanent organization.

The fundings need to be available on the right time and organizational approval processes must be followed (IPMA ICB4, 2015). Even though the accountability of the project could be in charge of the financing, the finance structure needs to be determined by the project manager. Financial reports are the output of the financial management system accounting for the proper ongoing of the financing of the project, linking this management the project cost structure, organizational cost structure and the time schedule. Not only processes need to be managed, but also roles and responsibilities. Key performance indicators (KPI) can be used for controlling.

The goal of controlling is to enable timely reactions to deviations, comparing planned cost against actual costs. The actual costs could include not accounted costs such as organizational costs, liabilities, etc. Underspensing and overspensing are also identified, as well as forecasts are made. So that all these tasks can be done, knowledge along with skills and abilities are provided, shown in Table 2.

The key competence indicators for finance are indicated in a process diagram in Figure 9. This diagram could be used as steps to follow to be able to choose the best finance sources and structure. The financial constraints are also mentioned within the Resources (Practice 8) competence, as the financial constraints do affect the optimization of the use

of the resources (IPMA ICB4, 2015). In this sense, some kind of resources, conflicts in availability may occur due to for example funds shortage. In terms of Procurement (Practice 9), the sharing of funds can be included in the procurement route chosen.

Once the project is ongoing, the finance tasks cannot be forgotten due to the necessity of changes that may appear along the project life cycle. So that the changes are monitored, and actions can be taken on time, the IPMA ICB 4.0 covers a competence called Plan and control (Practice 10) in which the monitoring processes gather information regularly on progress, finances and utilization of resources compared with baselines (IPMA ICB4, 2015). For this competence, the decision for fund is considered to be knowledge, and the earned value analysis, related to the difference between the planned costs and the actual costs, is considered as a skill or ability.

Knowledge	Skills and abilities
Financial accounting basics	Convincing/negotiating with sponsors
Cost estimating	Scenario techniques
Design-to-cost/target costing	Interpreting and communicating the actual cost situation
Processes and governance for cost management	Developing financial forecasts and models
Methods for monitoring and controlling expenditures	Writing skills
Performance indicator	Presentation skills
Reporting standards	Reading financial statements
Forecasting methods	Interpreting financial data and identifying trends
Financing options	Financial management approach
Funding sources	Developing a project budget
Financial management concepts and terms	Setting frameworks for resource project cost estimation
Contingency approaches	Directing and authorizing cost strategies and cost management plans
Relevant conventions, agreements, legislation, and regulations	Developing and maintaining cost management systems
	Conducting analysis, evaluating options, and implementing responses to project

Table 2 – Knowledge, skills and abilities for finance of projects

For the key competence indicator “Start the project and develop and get agreement on the project management plan”, the budget is part of the necessary information for the controlling and monitoring plan, but also the necessary resources and budget need to be made available for the initiation of the project along with the validation of the plan. With the initiation of the project, the detailed cost plan is updated to then control and adapt it to changes if necessary.

As for the Risk and opportunity (Practice 11) concerns, the relation of this practice with the finance can be found through the cost of contingency plans, expected monetary value and sensitivity analysis. Many times, the executive is the supplier of funds and/or can decide on resources (IPMA ICB4, 2015). Hence, a good relationship and open

communication should be established, since as stated in IPMA ICB 4.0 “With these primary stakeholders, expectation management is of the utmost importance.” (IPMA ICB4, 2015). The relation of the Finance (Practice 7) with other competence domains is as shown in Figure 10.

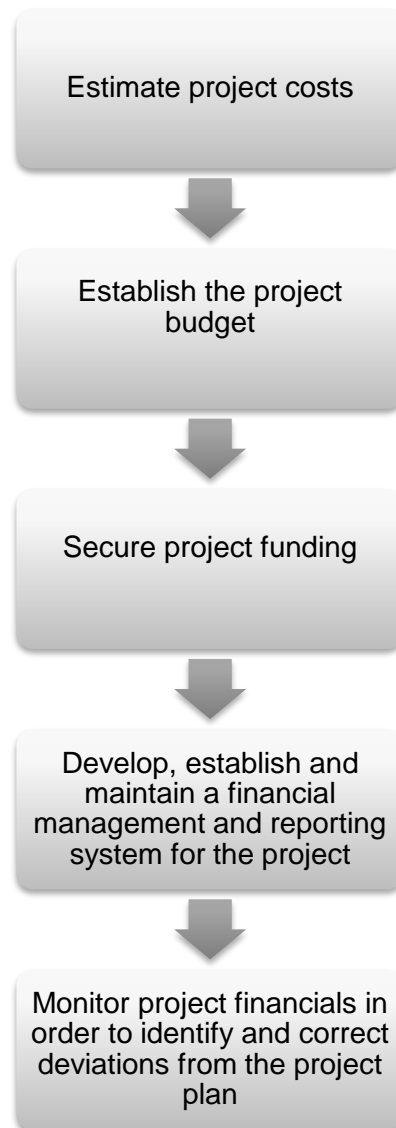


Figure 9 – Finance practice key competence indicators (Source: IPMA ICB4)

As stated within the key competence indicator “Align the project with finance and control processes and functions”, there are some mandatory rules, procedures and guidelines that need to be followed provided by the finance and control structure within the organization. “Knowing these rules and how to utilize them effectively and efficiently are crucial for the individual for successful funding, monitoring and/or reporting on financial topics.” (IPMA ICB4, 2015). When planning a finance, it is necessary to know how to apply for, justify, manage, and report on financial resources, as well as how to manage, administer, distribute, monitor, and manage finances, for what it is important to be aware of different financial models for funding. The measures that IPMA ICB 4.0 provides for the key competence indicator “Align the project with finance and control processes and functions” so that the financial task can be done are:

- To know the processes of the finance and control function.
- To be able to distinguish between the compulsory and optional utilities of the finance and control function.
- To monitor and control whether rules, guidelines and other financial utilities are effectively and efficiently used in projects to the benefit of the project.
- To communicate and report the status and trends of financial tasks clearly and objectively.



Figure 10 – Relation of Finance (Practice 7) competence with perspective competence domain (Source: IPMA ICB4)

Finally, a relation to the standard ISO21500:2012 processes with the competences is provided in the standard. The correspondences with the Finance (Practice 7) can be seen in Figure 11.

B4 competence elements	ISO21500 correspondence
Practice 7: Finances	(3.11 Project constraints) 4.3.25 Estimate costs 4.3.26 Develop budget 4.3.27 Control costs

Figure 11 – Correspondence to ISO21500:2012 processes for the Finance

4.1.3 ISO21500:2012

ISO21500:2012 provides high-level description of concepts and processes, a set of interrelated activities, that are considered to form good practice in project management (ISO21500:2012, 2012). The standard also states that “Project management is the application of methods, tools, techniques and competencies to a project” (ISO21500:2012, 2012), while the Project manager is defined as the one “who leads and manages project activities and is accountable for project completion” (ISO21500:2012, 2012).

Project are the mean to accomplish the organizational strategy, and they were born as a way of providing the way for taking advantage of opportunities. The ISO21500:2012 provides a process of creating value in which the financial aspects do appear while evaluating opportunities and initiating the projects. The opportunities should be transformed into benefits, and these benefits or goals are the justification for the investment in the project, which usually is done through the business case document. The approval process includes the financial investment appraisal techniques.

ISO21500:2012 includes the cost as a project constraint that the project deliverables should be related to apart from fulfilling the requirements. The availability of the project budget is among the constraints too. Other two constraints could also be related to the finance of the project as they do affect the economic estimations, that are, the level of acceptable risk exposure and the laws, rules, and other legislative requirements. Finance discipline is supported by the support processes, which are not addressed by ISO21500:2012, even though the three types of processes, project management, delivery processes, and support processes could overlap and interact between them.

The standard processes are grouped in two different ways:

- Process groups for the management of the project.
- Subject groups for collecting the processes by subject.

Attending to the subject groups, two of them are of special interest for the finance of projects, with the processes inside belonging to the process's groups:

- Cost
 - 4.3.25 Estimate costs → Planning process group.
 - 4.3.26 Develop budget → Planning process group.
 - 4.3.27 Control costs → Controlling process group.
- Risk
 - 4.3.28 Identify risks→ Planning process group.
 - 4.3.29 Assess risks→ Planning process group.
 - 4.3.30 Treat risks→ Implementing process group.
 - 4.3.31 Control risks → Controlling process group.

Planning processes are used to develop planning detail, which should be sufficient to establish baselines against which project implementation can be managed and project performance can be measured and controlled (ISO21500:2012, 2012). Implementing processes are used to perform the project management activities and to support the provision of the project's deliverables in accordance with the project plans

(ISO21500:2012, 2012). The controlling processes are used to monitor, measure and control project performance against the project plan. Consequently, preventive and corrective actions may be taken and change requests made, when necessary, in order to achieve project objectives (ISO21500:2012, 2012). In Figure 12 the relations between the different process groups can be seen. The planning group interacts with the initiating group, the controlling, and the implementing group. This means that the estimating costs and developing budget processes are related to the inputs and outputs for them indicated in Figure 13. The controlling, like the implementing process group is related to the planning, implementing, and closing process groups, and therefore, also to the inputs and outputs associated to them.

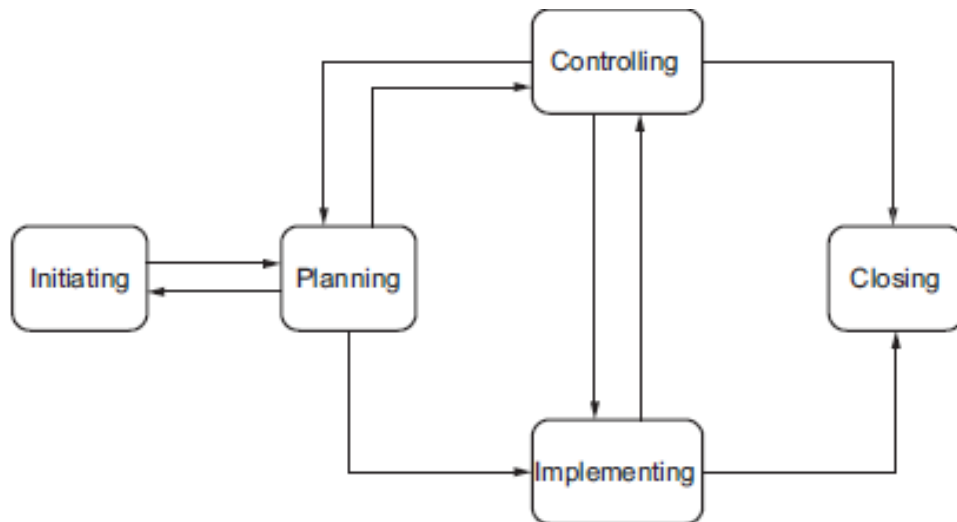


Figure 12 – Process groups interactions (Source: ISO21500:2012)

The cost subject group includes the processes required to establish the budget, to control costs and to complete the project within budget, while the risk subject group includes the processes required to maximize the probability of achieving the project objectives through proactive management of threats and opportunities. (ISO21500:2012, 2012).

“The purpose of estimate costs is to obtain an approximation of the costs of all the resources needed to complete each project activity and the cost of the project as a whole” (ISO21500:2012, 2012). It can be done with many different units such as labor hours or number of equipment hours in currency valuations. It can also be added the expected fluctuations of the currency value for long-term projects, as well as exchange rates should be included for projects with more than one currency. Reserve contingencies need to be added to deal with risks. The primary inputs are WBS, project plans and approved changes and outputs for the cost process are cost estimates and cost plan.

“The purpose of develop budget is to distribute the project’s budget to individual project activities or work packages” (ISO21500:2012, 2012). Cost estimation determines the total amount of money that will be expended within the project, while budgeting determines the amount of money that will be expended on each task, providing in this way a plan against which actual performance can be compared. Objective measures should also be established. The primary inputs are WBS, cost estimates, schedule, project plans and approved changes and outputs for the cost process are budget.

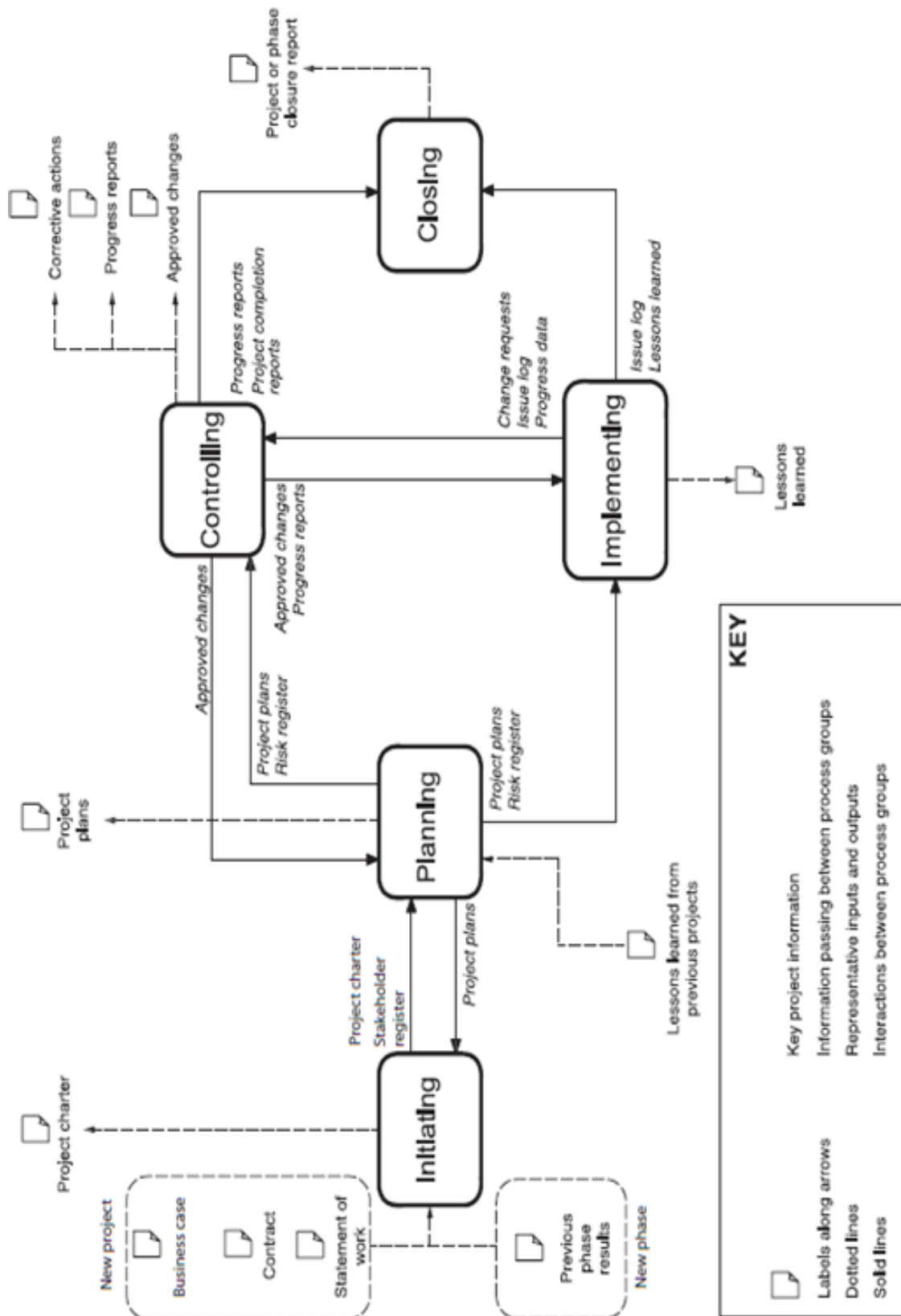


Figure 13 – Process group interactions showing representative inputs and outputs (Source: ISO21500:2012)

“The purpose of Control costs is to monitor cost variances and to take appropriate actions” (ISO21500:2012, 2012). The controlling of the present cost of the project, comparing it to the baseline cost, makes it possible to determine any variance, forecast the project cost at completion, or implement any corrective action if necessary. Control changes (4.3.6 Control changes) should be used to manage the changes in the cost baseline.

The data that needs to be accumulated with regards the performance to do the controlling once the work is started are budgeted cost, actual costs and estimated cost at completion. The data that needs to be accumulated to evaluate the cost performance is the scheduling data. The primary inputs are progress data, project plans and budget and outputs for the cost process are actual costs, forecasted costs, change requests and corrective actions.

“The purpose of identify risks is to determine potential risk events and their characteristics that, if they occur, may have a positive or negative impact on the project objectives” (ISO21500:2012, 2012). Between the two types of risk that can be identified within every project, the negative found ones are the ones that need to be addressed for contingency plans, the threats. The risks can change along the life cycle of the project, what leads to an iterative process that will be alive through all the projects. The primary inputs are project plan and outputs for the cost process is risk register.

“The purpose of assess risks is to measure and prioritize the identified risks for further action, such as the preparation of risk response plans” (ISO21500:2012, 2012). Risks are assessed for further actions if needed. The primary inputs are project plans and risk register and outputs for the cost process is prioritized risk.

“The purpose of treat risks is to develop options and determine actions to enhance opportunities and reduce threats to the project’s objectives” (ISO21500:2012, 2012). Risk responses are prepared, in which contingency plans can be included, introducing resources into the budget for example. The primary inputs are project plans and risk register and outputs for the cost process are risk responses and change requests.

“The purpose of control risks is to minimize disruption to the project by determining whether the risk responses are executed and whether they have the desired effect” (ISO21500:2012, 2012). In this way, the identified risks and whether the contingency plans are applied are monitored, as well as new risks arising through the life cycle of the project are treated if needed. The primary inputs are project plans, risk register, progress data and risk responses and outputs for the cost process are corrective actions and change requests.

Within the 4.3.2 Develop project charter process, ISO21500:2012 includes as a primary input the business case, along with project of statement of work. The document includes the justification for the project, as well as the needs, objectives, expected results and the economic aspects of the project. The standard further states that the “business case should include not only the financial analysis of the cost and benefits of the project, but also how the project aligns with the strategies, goals and objectives of the business.” The document should be reassessed throughout the project life cycle as changes could affect it. The project charter is the document that links the project to the strategic objectives, the primary output. The business case is also an input for the 4.3.2 Develop

project plans process. “The purpose of develop project plans is to document: why the project is being undertaken; what is to be created by whom; how it will be created; what it will cost; and how the project is to be implemented, controlled and closed” (ISO21500:2012, 2012).

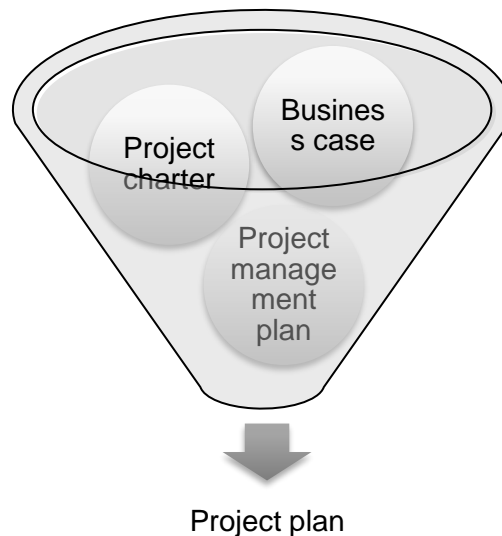


Figure 14 – Project plan inputs

In Figure 14, the documents of which a project usually does consist of are shown. They can be done as separated or as a unique document, but regardless of the structure, they should reflect the integration of at list:

- Scope.
- Time.
- Cost.

“The project management plan is a document or set of documents that defines how the project is undertaken, monitored and controlled” (ISO21500:2012, 2012). It defines among other the roles, responsibilities, organization, and procedures for the management of risks and costs. “The project plan contains baselines for carrying out the project, for example in terms of scope, quality, schedule, costs, resources and risks.” (ISO21500:2012, 2012)

4.1.4 PM2 guide

PM2 guide incorporates elements from a wide range of globally accepted project management best practices, captured in standards and methodologies (PM2 project management methodology Guide 3.0, 2018). It describes Project management as the activities of planning, organizing, securing, monitoring, and managing the resources and work necessary to deliver specific project goals and objectives in an effective and efficient way. Many competences are mentioned for a project manager or a business manager, but any of them is clearly stating the financial management skill despite the ability to create budgets is mentioned. Nevertheless, it is pointed out that every project’s most important aspect is to achieve the intended benefits and not the deliverables.

The financial resources related to a project are mentioned within the project portfolio management chapter as it is considered to be the addition of several projects and programs so that the resources intended for each including the financial ones are better controlled in terms of strategic objectives. For the standard, at this higher level is where the investment decisions are made, resources allocated, and priorities identified.

The standard defines 5 stages within every project, initiating, planning, executing, monitoring, and controlling and closing, Figure 15. The assignment of the financial resources and the management of these are mainly done within the initiating and planning phases, even though changes can occur in following phases.

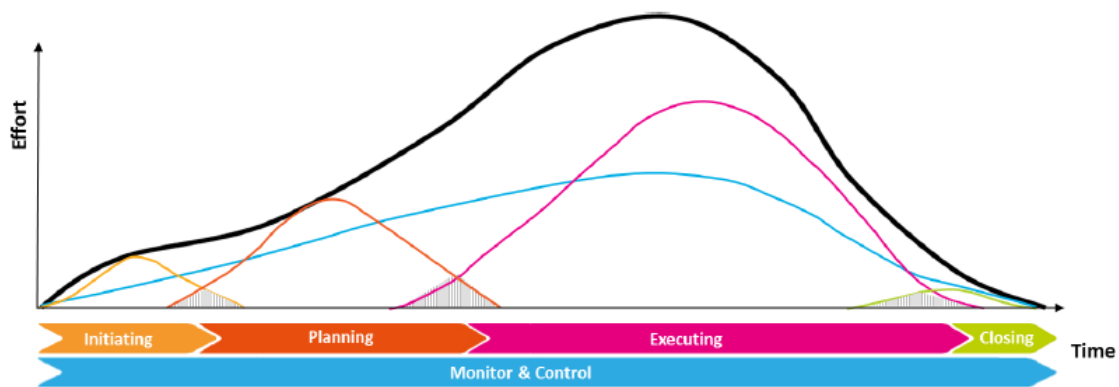


Figure 15 – The PM2 project lifecycle (Source: PM2 guide)

In the initiating phase the people involved formulate the project's objectives, ensure the project's alignment to the organization's strategic objectives, undertake some initial planning to get the project off to a good start, and put together the information required to gain approval to continue to the planning phase (*PM2 project management methodology Guide 3.0, 2018*). The input is the client request, while the output are the project initiation request (formalizes the commitment to explore a problem, need or opportunity further and captures the context), the business case (captures the reasoning behind the project, provides justification and establishes the budgetary constraints) and the project charter (builds on the business case and defines the project scope, high-level requirements and deliverables), documents that will be reviewed to decide whether the project keeps going or not. Related to the financing, in the planning phase, the project work plan is developed. It contains the project scope and appropriate approach, a schedule for the tasks involved, estimation of the necessary resources and detail of the project plans.

The standard provides some PM2 guide mindsets, which are the glue that holds the PM2 guide processes and practices together. They provide a common set of beliefs and values for all PM2 guide practitioners, within which questions that are useful to be sure of the project ongoing are given. One of these questions is related to the funds as the project shouldn't be done at any cost or risk showing respect for people's work and organizational funds and avoid high-risk behavior and tactics (*PM2 project management methodology Guide 3.0, 2018*).

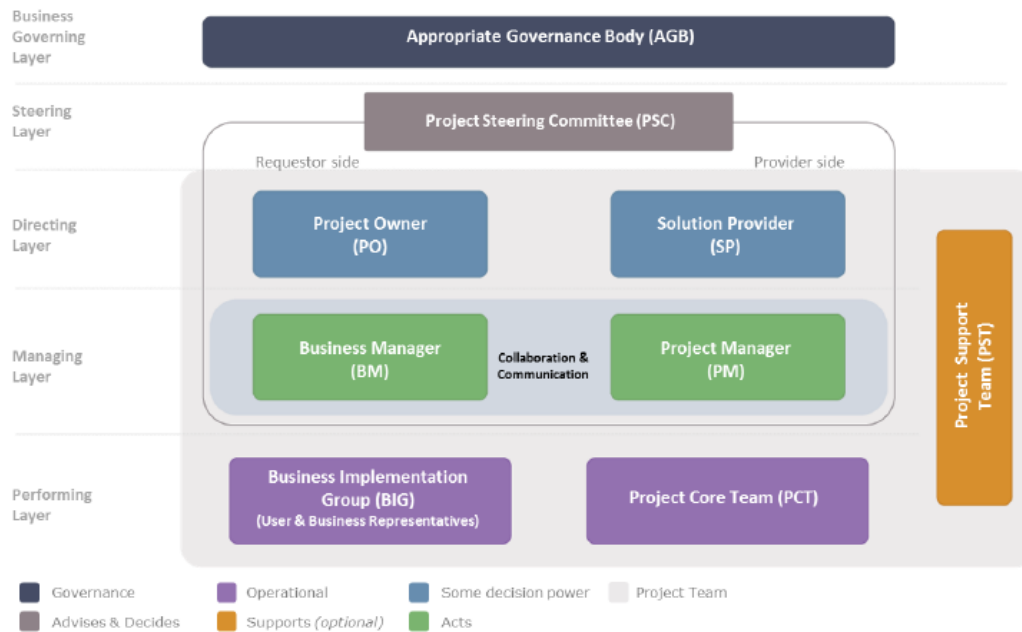


Figure 16 – Project organization (Source: PM2 guide)

For the PM2 guide standard just the top-level business governance layer, Figure 16, is the one related to the investment decisions and resources allocation, and thus, releases the funding requirement after approving the project and stating the objectives. The directing layer is the one in charge of the business case, mobilizing the necessary resources and monitoring the project’s performance to reach the objectives, while the project manager is more related to the day-to-day work management to produce the deliverables.

The initial cost estimated for the project, which is a driver for the funding decisions, is drafted in the project initiation request. Attending the Responsibility Assignment Matrix (RAM or RASCI) the Product Owner (PO) will delegate the duty to the business manager (BM). Anyway, the PO is accountable and supports the document creation, while the Appropriate Governance Body (AGB) and the Solution Provider (SP) are kept informed of the progress,

Figure 17. The AGB or the PO, depending on the project, approve to move onto the business case.

RAM (RASCI)	AGB	PSC	PO	BM	BIG	SP	PM	PCT
Project Initiation Request	I	n.a.	A/S	R	S/C	I	n.a.	n.a.

Figure 17 – Project initiation request (Source: PM2 guide)

The business case provides a deeper insight into the alignment of the project with the strategic objectives of the organization justifying the investment in time and effort to be made. The budgetary needs are also set, as well as impacts and risks analysis additionally to a cost-benefit analysis. It is a document that should be kept updated since it can change through the project’s life. In Figure 18 the roles for each participant are defined. The BM is still responsible, supported by the SP and the Project Manager (PM),

while the PO is accountable and the AGB or the Project Steering Committee (PSC) are the bodies that will approve it.

RAM (RASCI)	AGB	PSC	PO	BM	BIG	SP	PM	PCT
Business Case	I	C	A	R	C	S	S	n.a.

Figure 18 – Business case (Source: PM2 guide)

Many solutions can be found for each business case, and therefore, a cost-benefit analysis should be done for each of them. The higher the level of investment to be made, the higher the level of the analysis required for the business case. The project strategy to be followed should also be included.

The last document containing information for the funding is the project charter, also an output of the initiating phase. It is based on the latter two documents and is more project oriented. The objectives by means of scope, time, cost, and quality, as well as the risks, constraints and project milestones and deliverables are reflected in it. The PM guide is responsible for this document, supported by the BM and SP. The PO reviews the document and finally, the AGB or the PSC are accountable to approve it.

RAM (RASCI)	AGB	PSC	PO	BM	BIG	SP	PM	PCT
Project Charter	I	A	C	S	C	S	R	C

Figure 19 – Project charter (Source: PM2 guide)

During the planning phase, many documents are created, but related to the funding, the project work plan contains the effort and cost estimates. These outlines expectations of the resources needed, and the time required to complete each project task, within the constraints of resource availability and capabilities. The effort and duration estimates are used to create the project schedule and budget. The cost estimates are also an input for the schedule development. As specified by the PM2 guide in Figure 20, the PM is the responsible.

RAM (RASCI)	AGB	PSC	PO	BM	BIG	SP	PM	PCT
Project Work Plan	I	A	C	S/C	C	C	R	S/C

Figure 20 – Project work plan (Source: PM2 guide)

During the executing phase, the project ongoing is monitored in various aspects. One of them is the effort and / or cost, which is reported in the form of the project status report and project progress report. The former document is produced by the PM and submitted to the PSC providing a summary of the project performance (it is not a detailed task-level informative document). It should include tracking information on costs, scheduling, scope/changes, risks and issues, report on the status of important milestones for the current reporting period and provide forecasts for future reporting periods (*PM2 project management methodology Guide 3.0, 2018*). On the other hand, the project progress report does give a high-level overview of the project and its status including an overview and additional details. The budget and costs are included in both. These ongoing documents allow for decision making by means of funding requirements while the project is being executed.

During all the phases of the project life cycle, monitoring and controlling activities are carried out as per Figure 21. Within those activities, cost control is included, as well as risk management, or issues and decisions in addition to business implementation controlling. All these activities affect somehow the funding decisions to be made but could not be the only ones.

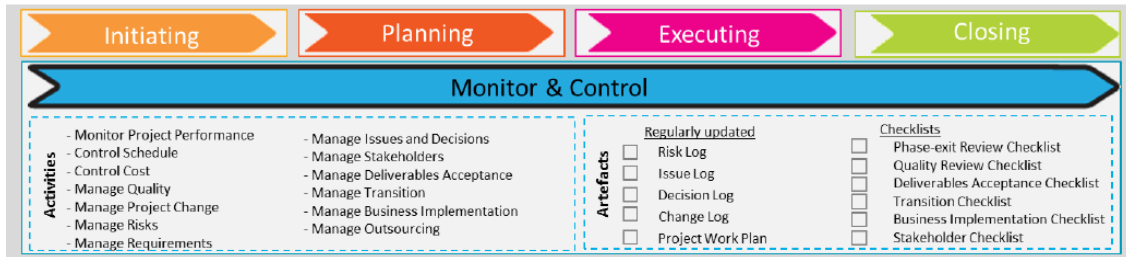


Figure 21 – Monitoring and control (Source: PM2 guide)

Activity	Affection to funding
Monitor project performance	The cost and risk dimensions are tracked by the PM forecasting their evolution.
Control cost	The PM regularly monitors the budget and tracks the difference between the planned against the actual and expected. The PSC is informed if the budget is at risk so that corrective actions are undertaken. Considerable cost overruns shall be justified, reported, and approved by the PO or the AGB.
Manage project change	The changes to be implement should be assessed for the impact by means of objectives, schedule, cost, and effort.
Manage risk	Negative risks can be turned into cost overruns that should be taken into account and monitored.
Manage issues and decisions	Negative issues can be turned into cost overruns that should be taken into account and monitored.
Manage business implementation	The business implementation activities should fall under the project's budget and control.

Table 3 – Monitoring and control activities and the relation to the funding

Further templates are given within the standard that highly affect the funding decisions like the risk management plan, issue management plan or risk log, issue log or decision log. Among the tools and techniques, some of them could be related to funding. The PESTEL analysis is used to understand how the environment might impact a project or an objective (PM2 project management methodology Guide 3.0, 2018). The risk likelihood / impact matrix is used for the risk assessment after they are identified. The WBS is a hierarchical division of the project into smaller work components that can be used to assign work or to estimate effort and cost, which is the base for the effort and

cost estimation technique. The three-point estimation technique is also used, in conjunction with Network Diagrams, to provide a weighted average of activity duration or cost. And finally, the EVM is a technique used to monitor and control the performance of projects, providing an objective view of performance based on the project financials.

4.1.5 PRINCE2 training manual

The PRINCE2 training manual is a principle-based methodology containing seven principles and six variables or performance targets, which are treated during the planning, delegation, monitoring and controlling of the project, Figure 22. Four are the main parts in which the manual is structured, principles, themes, processes, and tailoring. The standard states that the project manager monitors how well the work is going according to the project plan, detailing the role as “to achieve project objectives within the targets set for time, cost, quality, scope, benefits and risk.” (*The PRINCE2 Training Manual, 2010*).

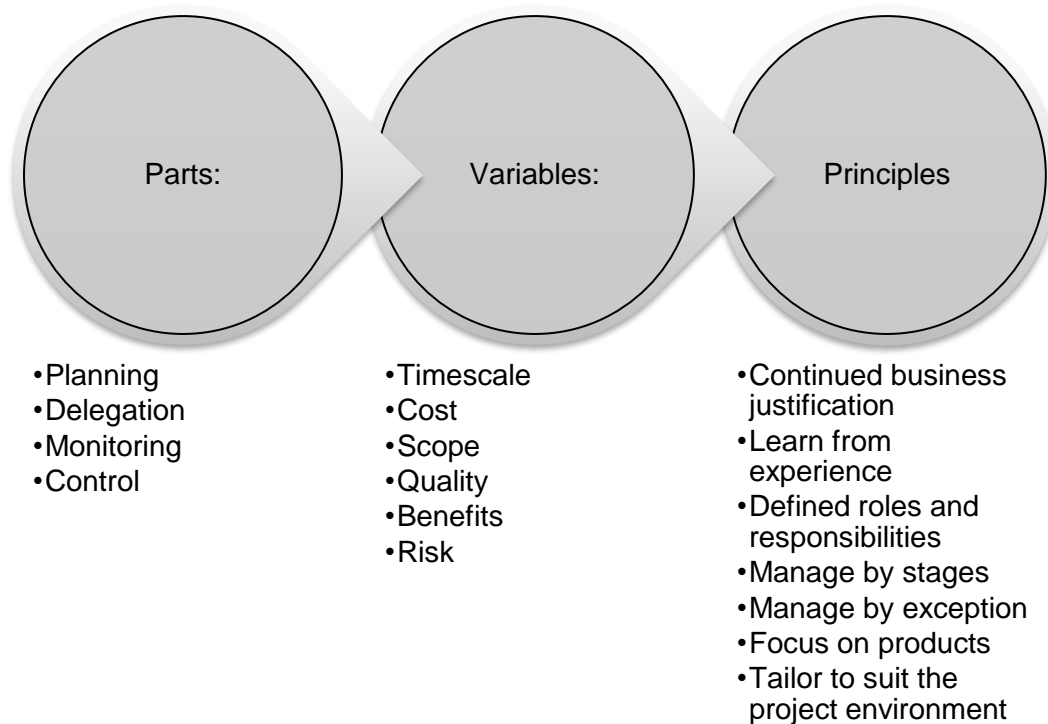


Figure 22 – PRINCE2 training manual structure (Source: PRINCE2 training manual)

The variable cost refers to the control of costs to keep the project within the budget since projects are always expected to give a return on investment, while the benefits are not strictly referred to as monetary benefits. Furthermore, the training manual does not cover specialist aspects such as how best to structure a financial project organization being a very generalist manual. The training manual does also state 8 benefits from implementing the method, within which, the benefit 6 states that “PRINCE2 continues to assess the viability of the project from a business case point of view and this happens throughout the project life cycle.” (*The PRINCE2 Training Manual, 2010*). It does also

provide a well-defined structure for reports and management products, being some of those products the business case and project plan.

For the PRINCE2 training manual, the business case is part of the responsibilities of the executive, even though it could be supported by the project manager or by a person from the financial department to assist with the financial information. The executive helps in this duty to be done in the second stage or initiation stage. The business case is reviewed and updated in the controlling stage. This document is not only mentioned in the timeline of a project, but it is also included in the principles, being the document used for the business justification in monetary terms.

The business case theme provides guidance on which and what this theme does. Three are the questions that should be addressed in the document, why the project, what are the business reasons and what are the benefits achieved for the organization. It is alive throughout the whole project life cycle proving that the investment is worth the continuity, it can also be called the “business justification”. The project mandate contains an outline of the business document, which will be expanded to the outline business case within the start-up stage, becoming then part of the project brief and finally turning into a separate business case in the project initiation stage. It is updated with cost, timeline, and product information once the project is initiated.

Four are the main characteristics that a business case should have: provide a structure or guidelines to be followed by the project; desirable, giving reasons for the project to go on; viable, justifying the possibility of carrying out the project; and finally, achievable, proving that the deliverables are possible to accomplish. As a summary, the next information is included within the business case as mentioned by (*The PRINCE2 Training Manual, 2010*).

- Reasons for doing the project as you would expect
- Estimate costs and timescale
- Benefits and dis-benefits
- Overview of risks

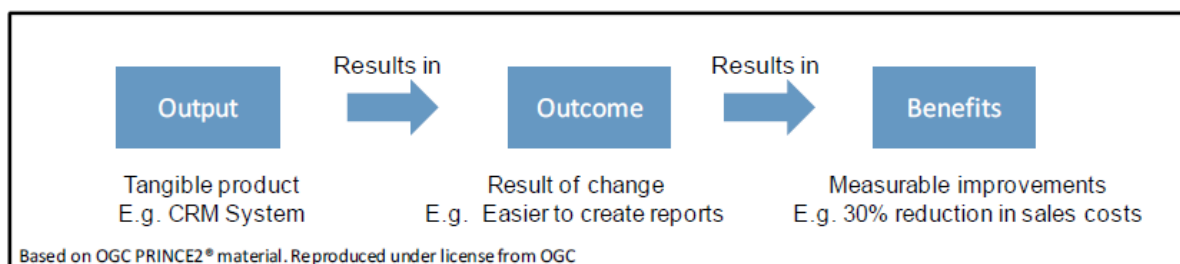


Figure 23 – Results of a project (Source: PRINCE2 training manual)

In Figure 23, the results expected from a project are shown. The outputs are the products that the user will deliver, while the outcome is the change for the user coming from the usage of the product. Finally, the benefits are the measurable advantages of using the product (*The PRINCE2 Training Manual, 2010*). They can be obtained during the project or after the project has finished. 5 types of business cases can be found within the standard depending on the project: compulsory project, not-for-profit project, evolving

project, customer / supplier project, and multi-organization project. The last aim of the project is to obtain the benefits, but always keeping in mind at the most possible reduced cost. The steps to be followed to create a business case are 4 of them; develop, verify, maintain, and confirm the benefits.

In the development step, Figure 24, which is done during the initiating phase, the executive is responsible for creating the business case with the input of the project mandate, as mentioned before, which sometimes contains the outline of the business case in the project brief. The detailed business document is a combination of the information about the costs, timescale, and product information from the project plan as well as from the risk register and project brief.

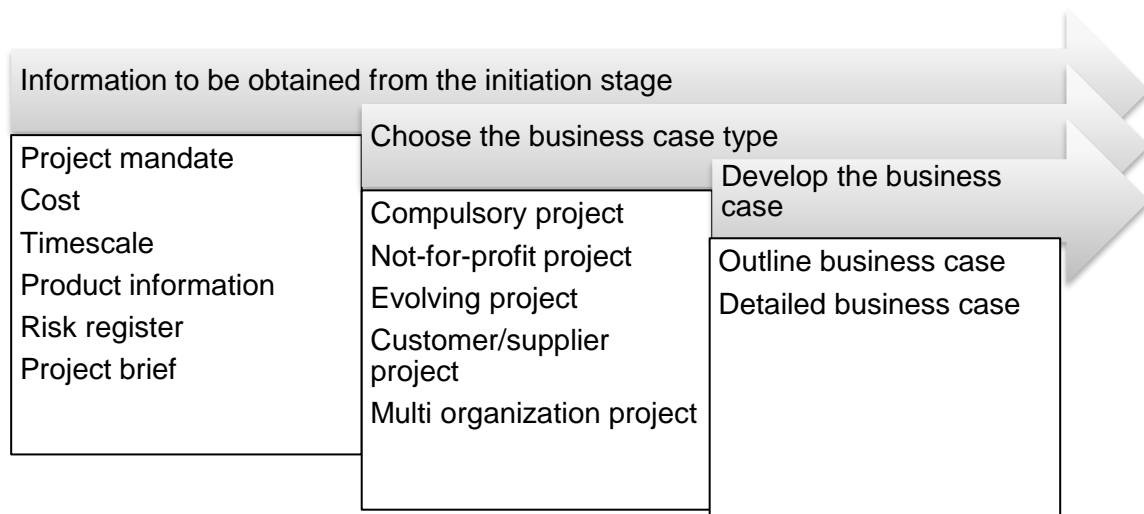


Figure 24 – Business case development

In the next step, the business case is validated several times during the whole project to verify that it is worthwhile (*The PRINCE2 Training Manual, 2010*). Figure 25 shows the verification points during a project. In overall, 7 are the most important validation points for the project board that, Table 4.

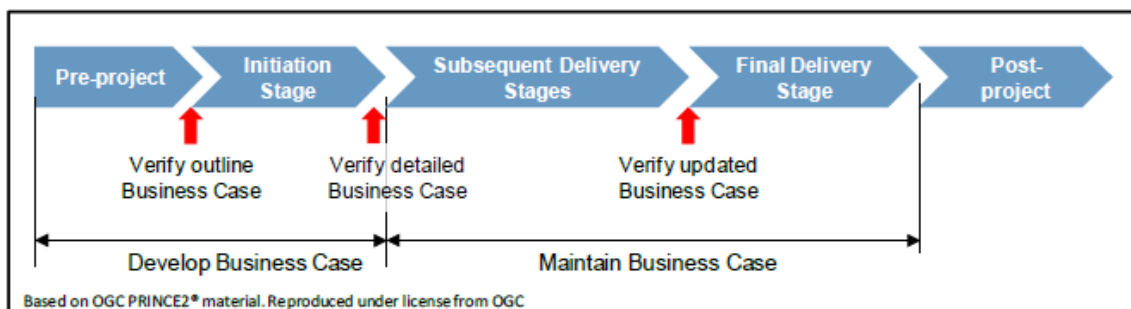


Figure 25 – Verification points (Source: PRINCE2 training manual)

During the maintenance of the business case step, it is kept up to date to reflect the state of the project, being a living document. The best moment to update it is usually the end of each stage. In evolving projects, some deliverables may already be put into products and therefore the project will be receiving some of the expected benefits, information to

be added into the business case too. The executive has the responsibility towards all project stakeholders to ensure that the project remains desirable, viable and achievable at all times. The business case is finally confirmed in the last stage in 4 steps (*The PRINCE2 Training Manual, 2010*):

1. Identification and documentation of the benefits by the senior user.
2. Select measure to prove the benefits.
3. Collect the baselined measures so that they can be used to compare the improvements.
4. Decide how, when and by whom the benefit measures will be collected.

Validation point	When
1	At the end of the “Starting Up a Project” process to see the value of the project.
2	At the end of the Initiation Stage so that the board decides to authorize the project or not.
3	During the Controlling a Stage process to include possible risks.
4	During the Controlling a Stage process to include changes in costs, timescales, risks or benefits.
5	At the end of each stage and before the next stage, the Project Board decides to release funds for the next stage to start. (<i>The PRINCE2 Training Manual, 2010</i>).
6	During the Closing a Project process, the Project Manager assesses the performance of the project in reaching its expected outcomes and benefits. (<i>The PRINCE2 Training Manual, 2010</i>).
7	After the project, a Benefits Review will be performed by someone from Corporate or Program Management. (<i>The PRINCE2 Training Manual, 2010</i>).

Table 4 – Business case validation points (Source: PRINCE2 training manual)

The PRINCE2 training manual also provides information on the content for a business case. Like any other document, the business case starts with an executive summary. In Figure 27 the following chapters are shown.

Finally, Table 5 shows the project manager main roles’ responsibilities with regards to the business case. Between the skills mentioned in the standard, good communication, cost management, an ability to understand the quality process, process change requests, document user needs, monitor the project, as well as planning, leadership, and team-building qualities, including teamwork, problem-solving, reporting, facilitating meetings and conducting workshops, in addition to the ability to anticipate problems and to be proactive in solving them are included.

The benefits are usually realized when the project is shut down by means of the benefits review plan, which is usually updated at the end of each stage. Once the project is

stopped it is usually the corporate or program manager, the one in charge of this document with the help of the senior user.

Role	Responsibility
Corporate or Program management	Project mandate
	Benefits review plan
Executive*	Business case
	Benefits review plan
Senior User	Specify the benefits and make sure they are realized by the project
Project Manager	Assist the executive in the creation of the business case internally.
	Impact analysis of issues and risks.
	Keep updated the business case and the benefits review plan at the end of each stage.
Project Assurance	Project ongoing audience
	Assist the executive in the creation of the business case externally.
	Verify and monitor the benefits review plan.

Table 5 – Roles and responsibilities business case related

The plan theme includes the costs answering to at how much will be necessary to produce the product cost. Finally, the progress theme refers to the control of the project to ensure the viability comparing the ongoing towards the business case.

On the other hand, one of the activities in the initiation stage is the outline business case creation, where the fundings are once more mentioned by the standard, and from which the realization of the project is decided. The executive prepares it to think on how the project will contribute to the company or program objectives, how the project will be funded, and how to best format the business case.

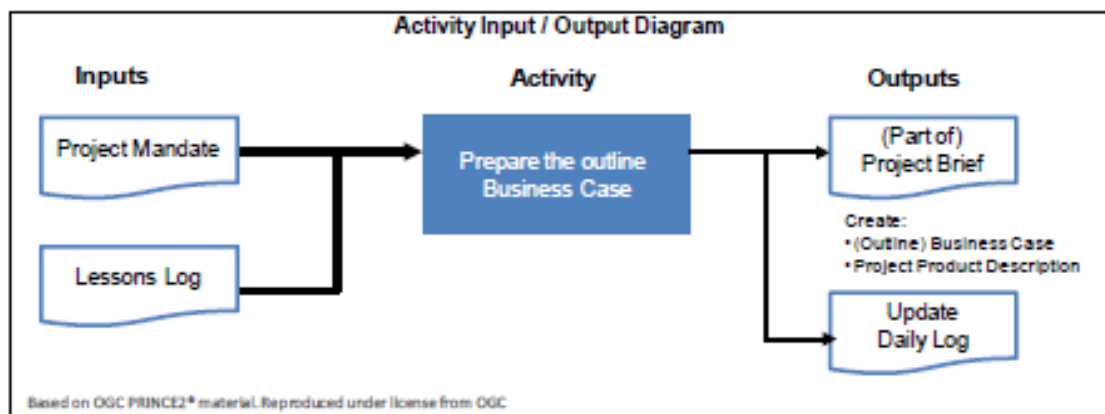


Figure 26 - Activity 4: Prepare the outline Business Case(Source: PRINCE2 training manual)

The risks and their management are also covered by PRINCE2 training manual in 5 steps in total: identify, assess, plan, implement and communicate. They should be included within the business case, and they can have a budget to cover them. In the assessment step, the risks are estimated and evaluated.

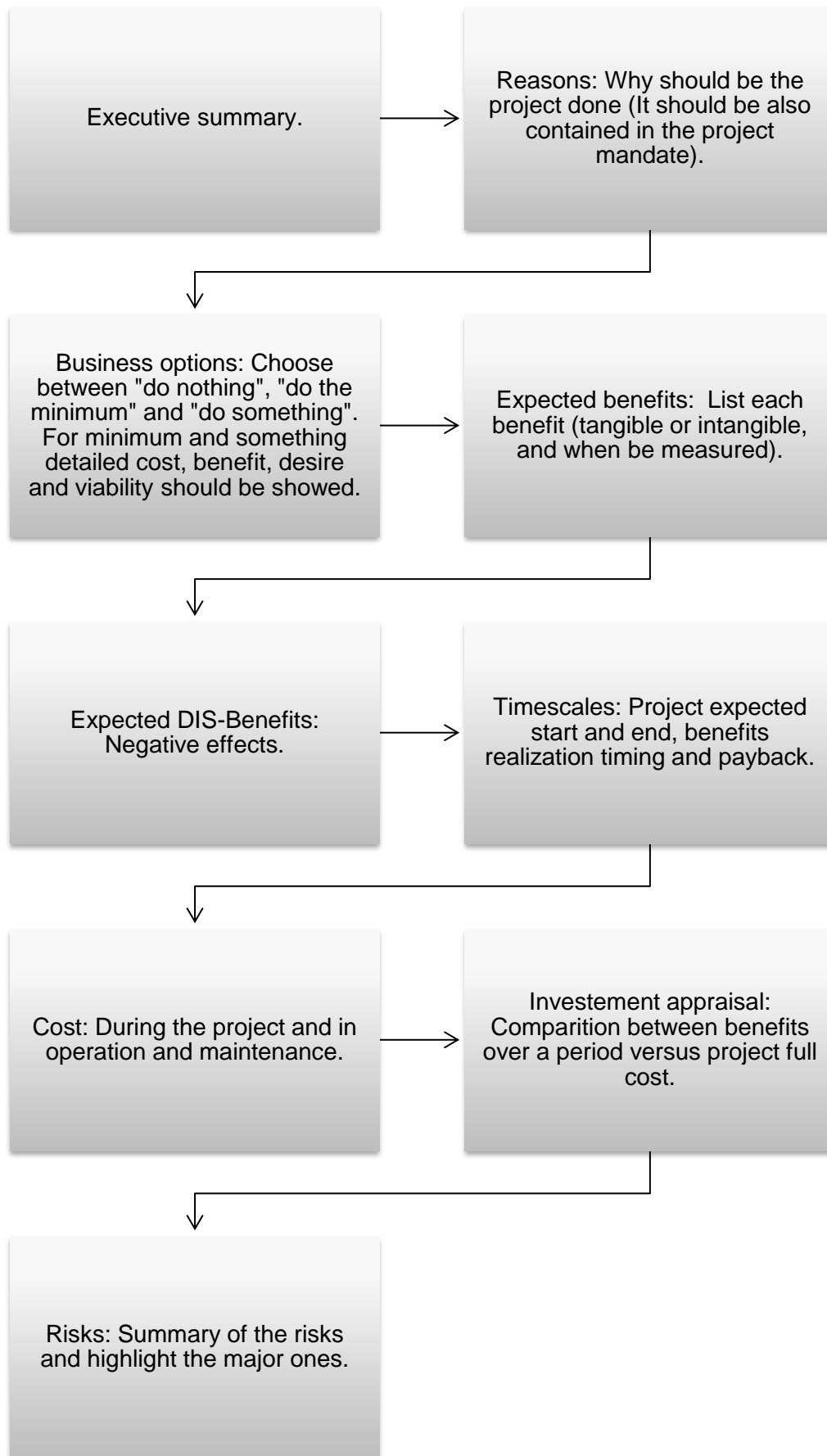


Figure 27 – Business case content

- Estimating is about assessing the probability, the impact, and the proximity for each threat or opportunity. These are three of the columns in the risk register. (*The PRINCE2 Training Manual, 2010*).
- Evaluating is to group all the risks together (both threats and opportunities) and get an overall risk value for the whole project. (*The PRINCE2 Training Manual, 2010*).

With the combination of these two actions, a risk budget can be obtained, which is just used for risks and should be kept just for that matter. Furthermore, PRINCE2 training manual states that “A Risk Budget is a sum of money that is put aside just to deal with specific responses to threats or opportunities and it cannot be used for anything else.” (*The PRINCE2 Training Manual, 2010*). This budget is convenient to be increased at the beginning of the project to cover any extra risk.

4.1.6 Comparison between PMBOK Guide Seventh Edition, IPMA ICB 4.0, ISO21500:2012, PM2 guide and PRINCE2 training manual

Through Table 6, Table 7 and Table 8, a comparison between the standards studied so far is given with regards to the most relevant aspects related to the treatment of the finance of projects within each of them.

Standard bases	
PMBOK Guide Seventh Edition	Principles and performance domains. Method, models, and techniques are provided and linked to each performance domain. Project managers are the focus, defining their responsibilities.
IPMA ICB 4.0	Domains and individual competences. Method, models, and techniques are provided but not linked to the competences. No specific role definition is given.
ISO21500:2012	Concepts and processes including primary inputs and outputs for each of them. Project managers are the focus, defining their responsibilities.
PM2 guide	Elements that are recognized best practices that included in other standards and methodologies. Specific roles are given including their expected responsibility on each phase activities and outputs. Tools and techniques are included.
PRINCE2 training manual	Principle-based methodology containing 7 principles and 6 variables or performance targets. 4 main parts. Project managers are not the focus, the project is seen as a whole for which all the roles are mentioned. The project manager roles is further extended.

Table 6 – Standard bases comparison

Guidelines for financing or related factors	
PMBOK Guide Seventh Edition	<p>No clear guidelines are given. Lack of clear financial management methodology affecting the finance of projects are provided.</p> <p>References to the factors cost, risk, taxes or control can be found through the text for the functions of the PM, as well as included within the domains and principles.</p>
IPMA ICB 4.0	<p>Financing methodology is provided with clear guidelines.</p>
ISO21500:2012	<p>Subject groups with processes related to the costs and risks management are included clearly within the planning, implementing, and controlling process groups.</p>
PM2 guide	<p>No clear guidelines are given. Lack of clear financial management methodology affecting the finance of projects are provided.</p> <p>References to the factors cost, risk and issues can be found through the text for each activity.</p>
PRINCE2 training manual	<p>No clear guidelines are given. Lack of clear financial management methodology affecting the finance of projects are provided.</p> <p>References to the factors cost, risk and or a extended business case development is included.</p>

Table 7 – Standard defined guidelines for financing comparison

Relations between other tasks and responsibilities	
PMBOK Guide Seventh Edition	<p>Relations between performance domains and at the same these to the principles are provided.</p>

IPMA ICB 4.0	The relations between competence domains and for different areas are given.
ISO21500:2012	Process relations between them are provided.
PM2 guide	Relations between activities are given as inputs and outputs of one and another.
PRINCE2 training manual	The principles and the variables are included on each step of the project phase where necessary.

Table 8 – Standard defined guidelines for financing

How to provide for the activity	
PMBOK Guide Seventh Edition	Methods and artifacts for the developing of the activities related to some factors that are intrinsic to the financing are provided, even though they are not directly related to each in the text.
IPMA ICB 4.0	Knowledge, skills and abilities, key competence indicators and measures are provided. Tools or techniques to develop them are not included. It is a what but not how to guide.
ISO21500:2012	Primary inputs and outputs are included for each process. Tools or techniques to develop the inputs or outputs are not included in the standard. It is a what but not how to guide.
PM2 guide	Tools and techniques as well as templates are included to develop the defined activities within the standard. It is a what and how to guide.
PRINCE2 training manual	Detailed techniques are not covered, activities for each stage are given. It is a what to but not how to guide.

Table 9 – How to provide for the activity on each standard

4.1.7 Construction Extension to the PMBOK® Guide

As the Construction Extension to the PMBOK Guide standard is mentioned by (Pinto, 2009) in his article, the financial management included in this guide is studied for being of high interest. It can also be said that the “Project management and many of its practices originate from construction projects and formed the foundation of the original 1987 document, The Project Management Body of Knowledge.” (*Construction extension*

to the *PMBOK guide, 2016*) The standard describes the generally accepted principles for construction projects that are not common to all general project types complementing the PMBOK guide.

The project manager role has many responsibilities among any type of project, but some specific ones are added for constructions projects within the (*Construction extension to the PMBOK guide, 2016*), which are:

- Leading.
- Communicating.
- Negotiating.
- Problem solving.

The most interesting responsibility from a finance point of view is the negotiating one, as in the standard is defined: “In construction, negotiating occurs around many issues and most often involves the exchange of money for the performance of services. Estimating the scope and cost of modifications to the contract, and negotiating the proposed costs, are just a few examples of where this expertise is needed. Anyway, through the life cycle of construction projects, four are the project manager financial management responsibilities areas:

- Accounting for financial resources of the project.
- Managing costs and profits.
- Managing cash flows.
- Making financial decisions or providing the necessary verified information to the project sponsor for making such decisions.

Regardless that in the standard some other aspects closely related to the financing are provided, like the project risk or cost management, this study will focus on the financial management area as the study of the construction projects is not within the scope. In chapter 15, the Construction Extension to the PMBOK® Guide indicates that the financial management area determines how the project will be financed, including the processes to acquire and manage the financial resources for the project. It also states that “It is more concerned with revenue sources and monitoring net cash flows for the construction project than with managing day-to-day costs.” the (*Construction extension to the PMBOK guide, 2016*). The type of finance is focused on privately funded construction projects.

The finance of projects can be seen from many different perspectives, from owner’s or from constructor’s perspective; the owner could belong to the public or private sector; projects can be small to medium size, large or megaprojects, and the financing could be short or long term, which have impacts on the financing decisions to be made. The financing needs to be effective and efficient to achieve objectives. The details of the ongoing of the finance of the project and the requirements, as for example for the payments or the initial costs set up, are included in the contract between the owner of the project and the contractor. Three are the major processes for the finance of construction projects:

- Financial Planning.
- Financial Control.

- Administration and Records.

Some of the stakeholders involved in the area are the management accountants, Certified Public Accountants (CPAs), Certified Financial Analysts (CFA) charter holders, sureties, insurance firms, banks, project investors, management consultants, etc (Construction extension to the PMBOK guide, 2016).

Financial management is distinctly different from cost management, which relates more to managing the day to-day costs of the project for labor and materials. In this section, the discussion is limited to financing the cost of the construction project itself, although long-term financing may include both construction and operation.

4.1.7.1 Financial planning

Financial planning is like any project planning. In this phase the financial requirements are set, along with assigning the project roles and responsibilities, tasks, resources, etc. In Figure 28 the inputs, tools and techniques, and outputs for the financial planning stage are provided:

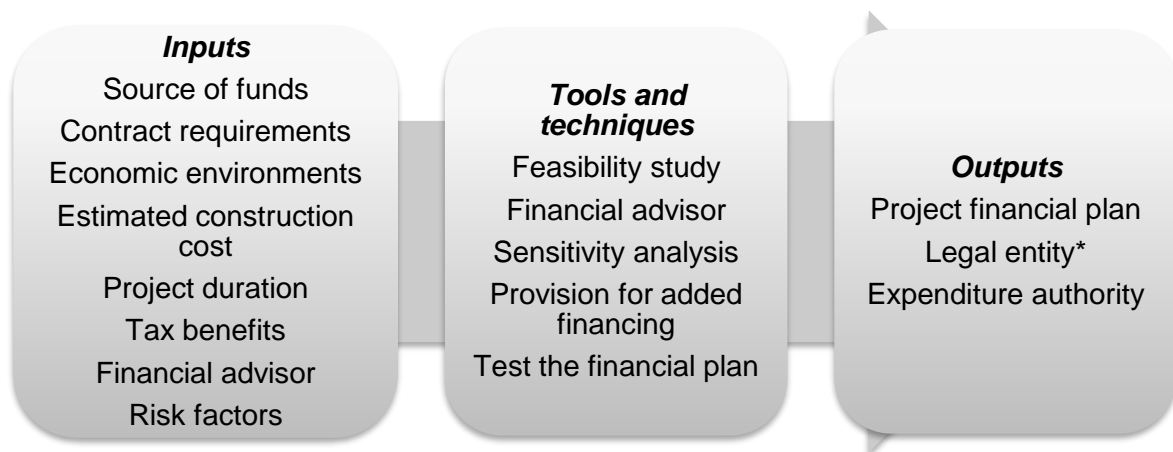


Figure 28 – Financial planning

The source of funds usually comes from the central financing system of the company, which may be a mix of borrowing from financial institutions, retained profits, and financial reserves. The financial institutions, that means public funding, used to ask for the next information to be verified and assessed before the money is granted:

- Scope, schedule, and budget
- Project objectives and benefits
- Return on investment
- Correlation to business strategic plans
- Ability to perform effective project management
- Realistic milestones to meet schedule dates and asset goals

As for the private funding, many sources could be found. The project financing may occur incrementally in different phases of the project. So that the proper ongoing of the project is ensured, the financial and project plans should consider the funding milestones. The funding sources selection depend mainly in project's creditworthiness and project

sensitivity to changes in interest rates. The most common sources for the construction projects are shown in Figure 29 Short term fluctuations may occur within the construction projects, for which some informal methods are used to conform the situation, Figure 30.

Common funding sources for construction projects	Senior debt
	Construction loan
	Subordinated debt
	Mezzanine financing
	Asset backed securitization (ABS) financing
	Project finance bonds
	Miscellaneous financing methods
	Project leasing
	Contractual (vendors/contractors finance)
	Preconstruction sales in real estate construction projects
	Factoring

Figure 29 – Construction projects main funding sources

Common methods to confront short term fluctuations	Overdraft facilities
	Lines of credit
	Payment delays
	Cost in excess of billings (underbilling) and billings in excess of costs (overbilling)
	Owner resources

Figure 30 – Short term fluctuation confronting methods

The economic environment, as mentioned in the Construction Extension to the PMBOK Guide, is an external factor that is outside the project manager’s control. Anyway, aspects like economic issues such as country risk or currency fluctuations need to be taken into account because they can either increase or decrease the project cost (*Construction extension to the PMBOK guide, 2016*). The analytical techniques, feasibility studies and sensitivity analysis will provide for long term projects the profitability of them within the given parameters as well as the viability with the cash

“For contractor-financed projects, the contract may contain important clauses that restrict the contractor’s ability to obtain favorable terms” (*Construction extension to the PMBOK*

guide, 2016) However, these terms can be negotiated since this type of projects are often awarded after a proposal process. The contract and the project plan help define the financial requirements.

A proper financial plan allocates risks among participants, investors, customers, and interested third parties. Some risks could be favorable for financing, and a risk analysis is usually asked by those institutions providing the fundings. But this is not the last aspect to consider when planning financing, as another important factor to consider in the financial planning of the project is that in many countries interest is tax deductible while dividends to shareholders are not. This factor encourages financial leverage over the use of equity as stated in (*Construction extension to the PMBOK guide, 2016*). A taxation structure should be created for the project studying the advantages of tax depreciation and other taxable revenues.

The project financial plan consists of a clear identification of the financial requirements and of the means to finance them. With this comprehensive document, all parties must understand by whom and when all the necessary equity, debt, and insurance are to be supplied. The expenditure authority is usually determined by organizational policies. that must also consider the fact that dual signatories and levels of spending and approval should be considered (*Pinto, 2009*).

* Legal entity is the definition of the legal form that the project will take; even though for this study is of no interest as this type of funding is not covered in the document.

4.1.7.2 Financial monitoring and controlling

This process ensures that financial control and cost control are executed in the most effective way to ensure that all items are within budget and the financial cash forecast. It can be said with other words, “financial control ensures that bonds are reduced when necessary, calls for funds from project partners are made as needed, and all insurance and bank withdrawals or deposits are performed at the appropriate times” (*Construction extension to the PMBOK guide, 2016*). In Figure 31 the inputs, tools and techniques and outputs for the controlling and monitoring can be seen.

“The project accounting system should be similar in structure to the WBS, showing the breakdown of the total project in more controllable modules” (*Construction extension to the PMBOK guide, 2016*). The controlling is done by comparing the actual spending and revenue against budget and cash flow forecasts so that deviations are found. Financial records need to be kept for proper controlling.



Figure 31 – Financial control

As quoted in the Construction Extension to the PMBOK Guide, either external or internal financial audits ensure correct accounting methods and financial practices are being maintained (*Construction extension to the PMBOK guide, 2016*). Unseen problems could arise from these audits. The basic financial statements are the prime focus, and the reports could contain warnings of overinvestment on fixed assets, poor credit arrangements, and improper use of project funds.

Regularly analyzing the cash flow data trends based on unique characteristics of the project could be obtained revising like that the forecasts for the remaining duration. Financial reports are also another monitoring and controlling tool, as “for projects that need full financing, management and any lenders involved require periodic financial reports.” (*Construction extension to the PMBOK guide, 2016*)

Experts could be added to the project so that advice is given. The Construction Extension to the PMBOK Guide states that “the use of professional expertise such as accountants, legal advisors, insurance and investment brokers, or others who will advise on issues related to monetary policies, investor relations, the stock market, wills, trusts, funds, etc., may add considerable value toward avoiding financial pains.” (*Construction extension to the PMBOK guide, 2016*).

Finally, evaluations such as Ex-Post evaluations could be done to measure the effectiveness and the aims fulfilment as it is said in the Construction Extension to the PMBOK Guide standard (*Construction extension to the PMBOK guide, 2016*). By analyzing different financial parameters, the proposed versus the achieved benefit is compared.

4.1.7.3 Administration and records

This process ensures that financial information is administrated and that records are well made. In Figure 32 the inputs, tools and techniques and outputs can be seen.



Figure 32 – Administration and records

4.2 A scientometric based analysis of the finance of projects for project management within the scientific bibliography

In addition to reviewing the available data within the most representative standards for project management, a scientometric analysis for the available bibliometric data for the topic is conducted. As mentioned by (*Oliveira et al., 2019*), “Bibliometric analysis is an indispensable statistic tool to map the state of the art in a given area of scientific knowledge and identify essential information for various purposes, such as prospecting research opportunities and substantiating scientific researches.” This study discusses

the most active research areas for the field, and, based on the assessment of the literature, future research is recommended. In Table 10, a summary of the documents found for each keyword with and without the chosen filters applied is shown. The searched keyword "financial risk assessment " resulted in most documents (1506), while "project investment appraisal" resulted in the least documents (35).

Keyword	Document results	Documents results after filters
Finance of projects	3528	436
Project cost estimation	1834	229
Financial risk assessment	9931	1506
Project benefit management	4149	542
Project investment appraisal	176	35
Total (summary of each)	19618	2748

Table 10 – Documents searched in Scopus database

Documents by subject area

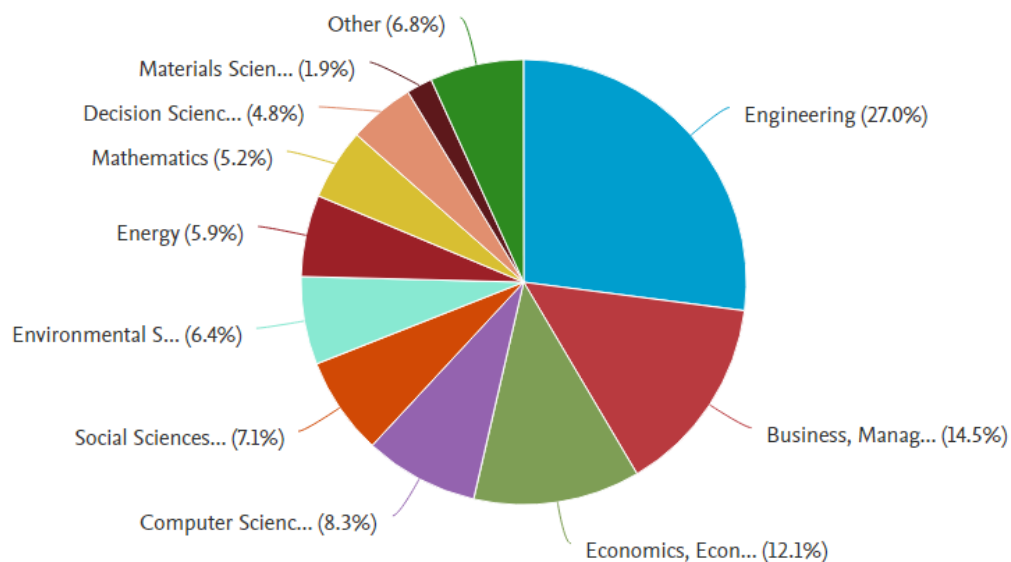


Figure 33 – Documents publication by subject area (Source: Scopus)

Anyway, when doing the searching as a single search with all the keywords included, the results are slightly different being the total amount of documents of 2559.

Besides, Scopus provides several options of analyzing the results. When looking at the results for the subjects' areas in which documents are published, with the filters applied for all the keywords included in a single search, the three selected areas resulted in the main areas with a 53,6% of the documents, Figure 33, what provides robustness to the study. Engineering is the main subject area with 1534 documents Most of the documents are articles, 2493, being the reviews just 66 of those documents.

4.2.1 Annual publication trend

The annual publication trend for each searched keyword for the last decade has been represented in Figure 34. In the diagram the total number of publications for each year it's been represented in a bar chart, to which the number of documents published for each keyword has been transposed with a line chart.

For the last decade an increasing publishing trend can be observed for the total amount of documents every year, increasing the number of documents published from 2012 to 2022 in approximately the double. In 2012 and 2017 a peak between can be observed anyway with regards to the next year. The period from 2018 to 2022, the last 5 years, could be used for the analysis since it seems to be a confirmed trend. The mentioned could be also confirmed with the diagram based in a single search for all the keywords shown in Figure 35.

It is important to mention here that there are possibilities of duplicate publications while searching different keywords that are also added in the sum of publications. This is a limitation in the study.

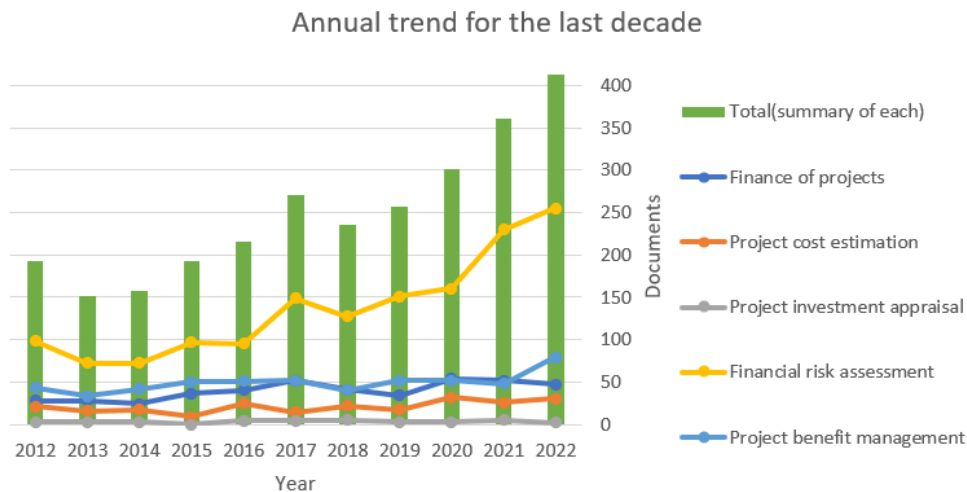


Figure 34 – Annual publication trend for individual search

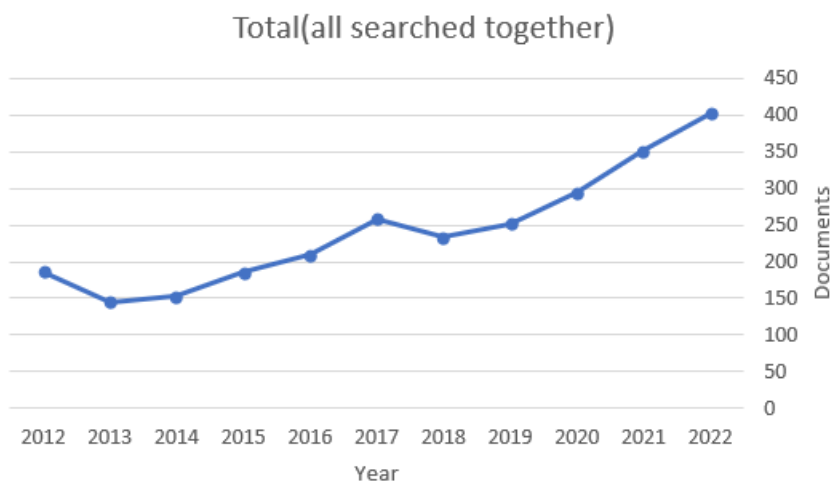


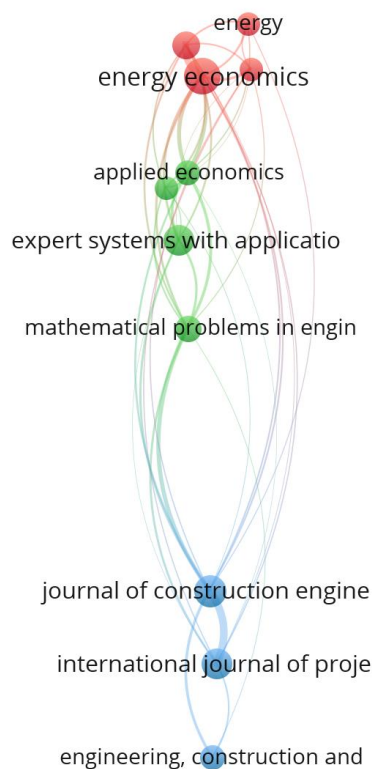
Figure 35 – Annual publication trend of articles for a single search

4.2.2 Top publication sources

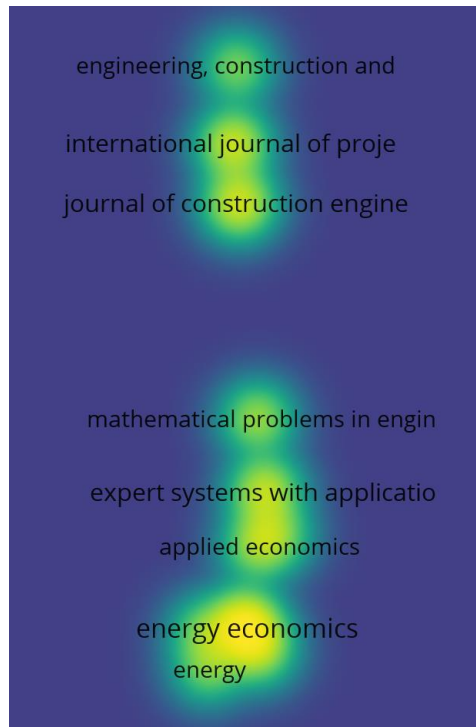
The depiction of development and innovation analysis is made possible by source mapping (Ahmad et al., 2021). The analysis is done by using VOSviewer with Scopus data file. "Bibliographic coupling" was chosen as the "analysis type," and "sources" was chosen as the "analysis unit". A source's minimum number of documents was set at 40, and from the 624 sources just 11 met the set parameters.

Table 11 lists the top sources/journals that published at least 40 publications providing data with the any of the keywords defined for the study, as well as their citation counts and total link strength. The top three journals in terms of published documents are energy economics, journal of construction engineering and management and international journal of project management with respective documents of 106, 79, and 74. However, the top three journals with respect to citation count were energy economics with 4585, expert systems with applications with 3208, and international journal of project management research with 1959 citations.

The network visualization and density visualization of sources with at least 40 articles published is shown in Figure 36. The node size corresponds to the contribution of the journal's article count; a bigger node size suggests a greater contribution (Ahmad et al., 2021). For instance, energy economics and journal of construction engineering and management have bigger nodes than the other journals, indicating their higher impact in the present research area. Furthermore, nodes (sources/journals) of the same color show clusters of connected journals detected using VOSviewer analysis. Three clusters have been observed shown by red, green and blue. Cluster 1 (red) comprised 4 items, cluster 2 (green) contained 4 items and cluster 3 (blue) with 3 items.



(a)



(b)

Figure 36 – Source mapping with a minimum of 40 publications in the research of finance of projects (a) network visualization (b) density visualization (Source: VOSviewer)

N/A	Source document	Documents	Citations	Total link strength
1	Energy economics	106	3208	733
2	Journal of construction engineering and management	79	1926	786
3	International journal of project management	74	4585	586
4	Expert systems with applications	68	1959	165
5	Resources policy	57	824	618
6	Mathematical problems in engineering	53	165	303
7	Applied economics	46	369	333
8	Engineering, construction, and	42	484	61

	architectural management			
9	Energies	41	463	70
10	Journal of cleaner production	40	1258	84
11	Energy	40	981	59

Table 11 – Top publication sources

The connecting links between the research sources reflect the number of publications that contain co-citations. In addition, the number of times two journals have been cited in the same article is shown by the connection strength (Ahmad et al., 2021). For instance, journal of construction engineering and management had the greatest references to other research sources (total link strength: 786). The connections between nodes (sources) that are near together in a cluster are stronger than those that are farther apart (Ahmad et al., 2021). For example, energy economics is more directly linked to resources policies than the others.

The results are in line with the analysis provided by Scopus. In Figure 37 the top 11 sources with more at list 40 documents published are shown in the Scopus database. The number of documents match with the ones added in Table 11.

Documents per year by source

Compare the document counts for up to 10 sources.

[Compare sources and view CiteScore, SJR, and SNIP data:](#)

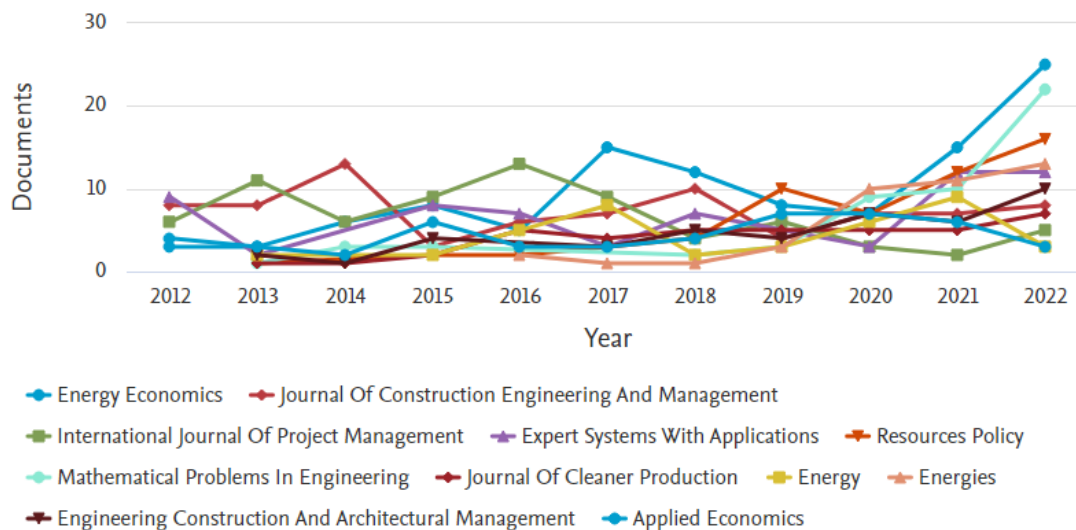


Figure 37 – Documents per year by source (Source: Scopus)

4.2.3 Most cited keywords

Keywords are important research materials because they identify and represent the research domain’s fundamental field (Ahmad et al., 2021; H.-N. Su & Lee, 2010) and they distinguish and emphasize the basic subject of the study domain (Khan et al., 2022).

For this analysis, "co-occurrence" was chosen as the "kind of analysis," and "all keywords" was chosen as the "unit of analysis", in VOSviewer. The minimum number of repetitions for a keyword was set to 15, and 44 of the 7548 keywords met the requirements with the set criteria. From these 44, Table 12 records the keywords with a minimum occurrence of 20.

N/A	Keyword	Ocurrence	Total link strength
1	risk management	131	79
2	project management	120	87
3	risk assessment	71	38
4	financial risk	55	29
5	risk	55	30
6	cost estimation	53	28
7	risk analysis	51	44
8	finance	46	31
9	construction management	42	25
10	credit risk	39	15
11	value at risk	38	14
12	portfolio optimization	37	11
13	machine learning	34	14
14	cost-benefit analysis	32	10
15	systemic risk	31	11
16	monte carlo simulation	29	26
17	uncertainty	29	27
18	construction	28	28
19	construction industry	27	24
20	optimization	26	21
21	financial crisis	24	9
22	sustainability	24	17
23	covid-19	22	3
24	simulation	21	16
25	construction projects	20	14
26	cost	20	21
27	crowdfunding	20	5

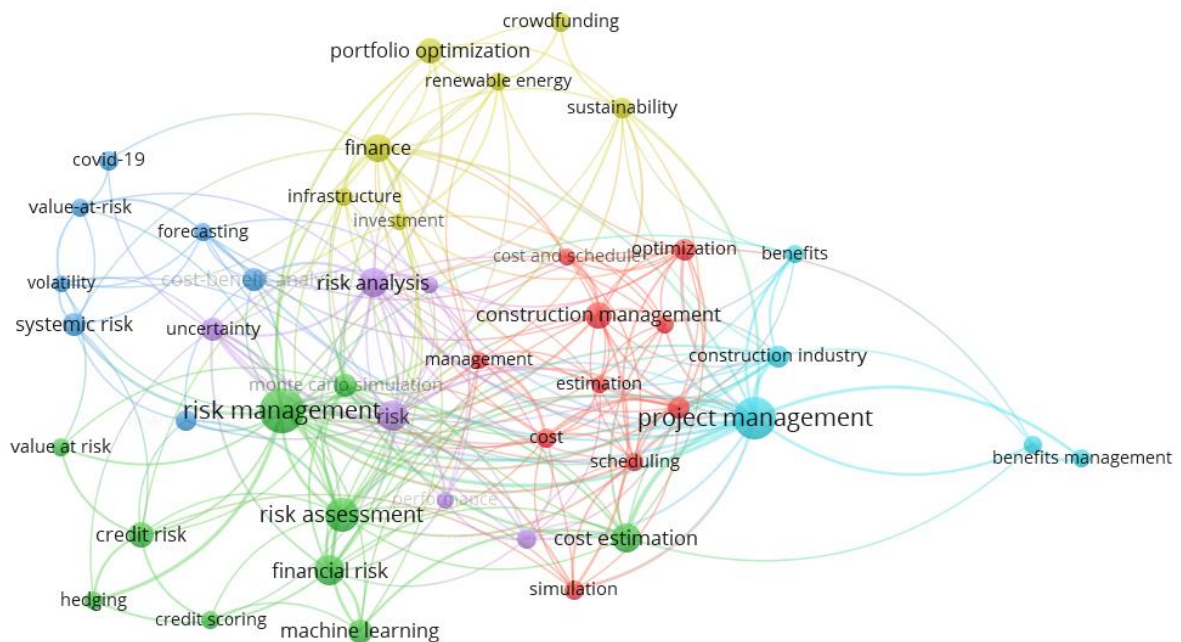
Table 12 – List of keywords with a minimum ocurrence of 20 in the research of finance of projects

The five most often occurring terms in the topic study field are risk management, project management, risk assessment, financial risk and risk. Figure 38 shows the co-occurrence visualization of keyword mapping, as well as their connections and the density associated with their correlation frequency. The size of a keyword node in Figure 38 (a) denotes its frequency, whereas its location denotes its co-occurrence in publications (Ahmad et al., 2021). In addition, the graph expresses that the top keywords

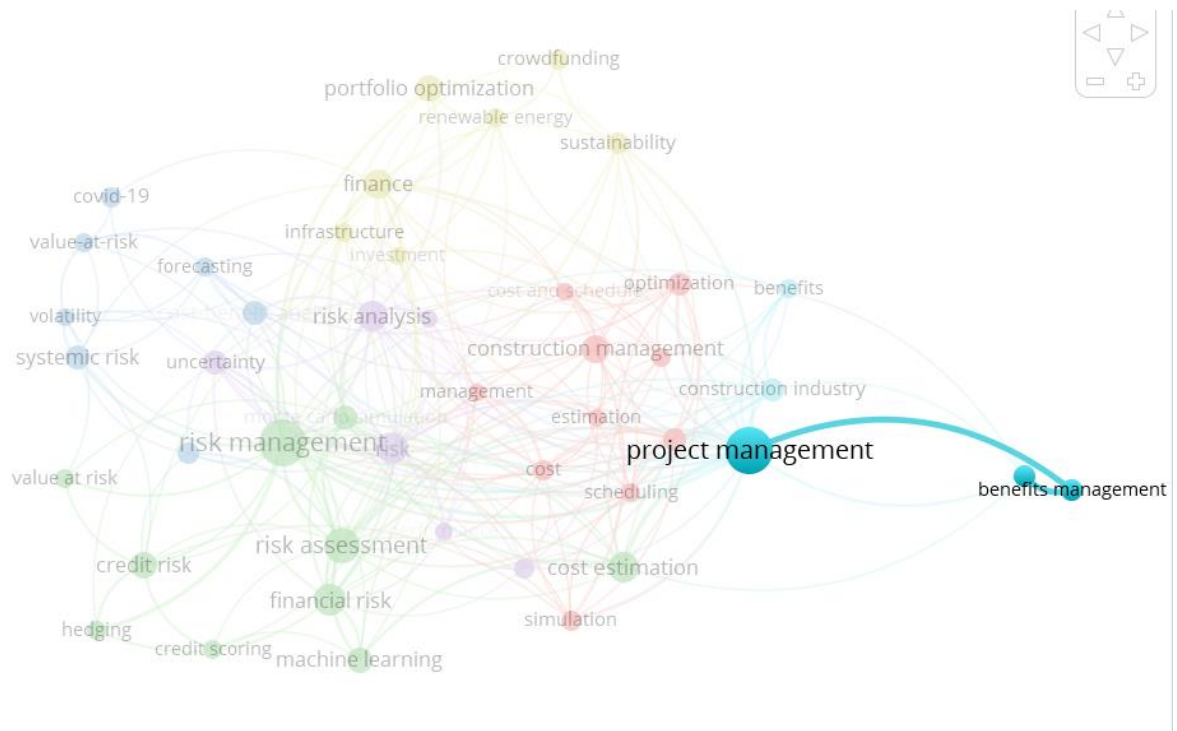
have larger frames than the rest, signifying that these are essential keywords for a real investigation in the research of finance of projects.

Clusters of keywords have been colored differently in the network to highlight their co-occurrence (Ahmad et al., 2021). The colors red, green, dark blue, light blue, purple and yellow were used to identify six clusters. Cluster 1 (light blue) contained 10 items, cluster 2 (green) 10 items, cluster 3 (dark blue) 7 items, cluster 4 (yellow) 7 items, cluster 5 (purple) 6 items and cluster 6 (red) 5 items. In Figure 38 (b), different colors represent the density concentration of keywords. Yellow, green, and blue are the colors in order of density, with yellow having the highest density and blue having the lowest. Risk management, project management, risk assessment, and other prominent keywords display yellow signals indicating a greater density of occurrences. This finding will help ambitious researchers select keywords that ease the discovery of published papers on a specific topic.(Khan et al., 2022)

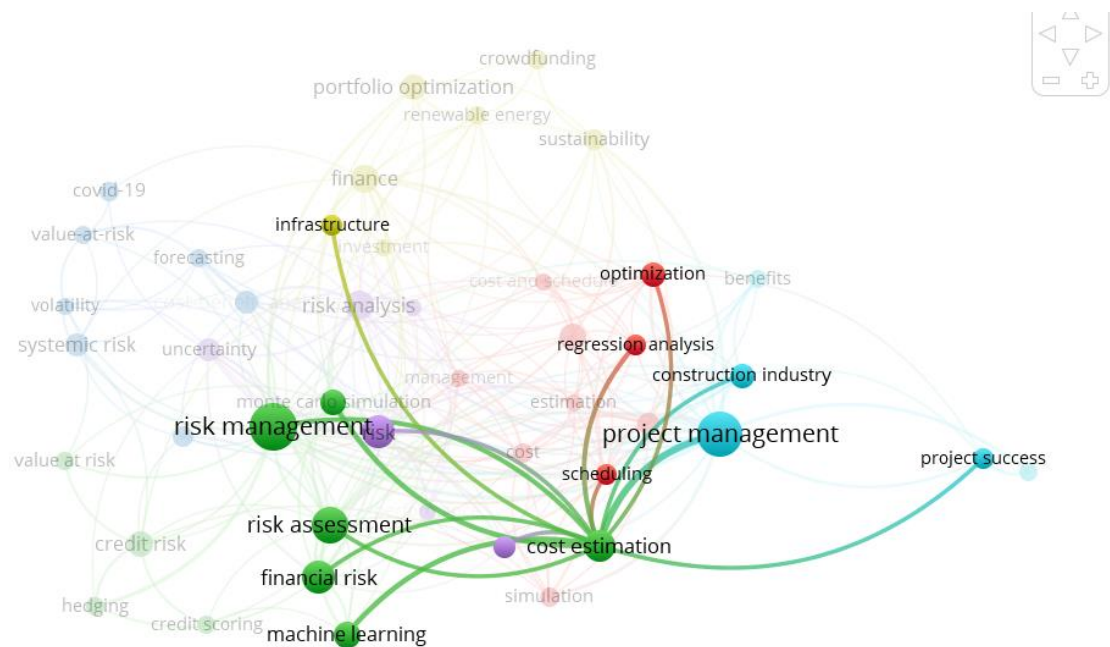
Figure 39 shows the links between the chosen keywords, even some of them are not the same, with other keywords. Finance is strongly linked with risk and project management, which at the same time is linked to benefits management. Both risk and project management are closely related to cost estimation too. Finally, investment is not so closely related to any keyword, but there is a good link with finance and risk management. This link also indicates that these keywords have been frequently used conjointly in the published articles.



(a)



(b)



(c)

an author was kept at the maximum that VOSviewer found that was 3, and 6 out of 2502 researchers satisfied this requirement. The authors with the most articles and citations in the field of geopolymers, as assessed from the bibliographic data using VOSviewer, are included in Table 13 according to data extracted from the Scopus database. The total number of citations was divided by each author's total number of publications to get the average citation count, and, additionally, the h-index for each author is calculated in Scopus. The h-index is used for displaying and comparing the productivity and impact of published work of scholars. (Ahmad et al., 2021; Khan et al., 2022). It is complicated to assess the effectiveness of a scientist when all parameters, such as the quantity of documents, overall citations, and average citations, are taken into account (Khan et al., 2022). Alternatively, the researcher's ranking will be evaluated separately for each component. Lefley F. has the most documents published, while Sousa V., Almeida N.M., and Dias L.A. have the most citations. When looking at the average citations, the highest average is given by Sousa V., Almeida N.M., and Dias L.A.

N/A	Keyword	Documents	Citations	Average citations	Scopus h-index	Total link strength
1	Lefley F.	4	20	5	10	0
2	Cheng M.-Y.	3	79	26	37	0
3	Tran D.-H.	3	79	26	33	0
4	Sousa V.	3	209	70	43	0
5	Almeida N.M	3	209	70	11	0
6	Dias L.A.	3	209	70	5	0

Table 13 – List of authors having a least 3 publications in the research of finance of projects

cheng m. y. tran d.-h.

sousa v.; almeida n.m.; dias l

lefeley f.

(a)

cheng m.-y.; tran d.-h.

sousa v.; almeida n.m.; dias l

leffley f.

(b)

Figure 40 – Co-authorship science mapping: (a) Visualization of top contributing authors (b) Visualization of connected authors (Source: VOSviewer)

Figure 40 depicts the association between writers with at least 3 publications and the most notable authors. Figure 40a shows the scientific mapping of reserachers who have contributed at least 3 papers to the current field of study. Figure 40b shows the largest group of related writers based on citations. No link have been found between them as shown in Table 13 with a total link strength for each author of 0.

4.2.5 Most cited articles

The number of citations a publication receives signifies its impact in a certain research domain (*Khan et al., 2022*). Articles with a high number of citations are regarded as landmarks in the field of research (*Ahmad et al., 2021*). To analyze documents based on citations, the "type of analysis" was set to "bibliographic coupling" and the "unit of analysis" to "document" in the VOSviewer. A document's minimum citation count was set at 80, and 90 of the 2539 documents (excluding duplicates) met this requirement. Table 14 lists the top 20 most cited research articles, as well as their authors, publication year, and total link strength.

Netemeyer R.G (*Fernandes et al., 2014*) obtained 757 citations for their publication " Financial literacy, financial education, and downstream financial behaviors ". Volm J.M (*Bryde et al., 2013*) and Wang G. (*Kou et al., 2014*) received 728 and 588 citations for their respective papers and were listed in the top three. Only 3 articles in this field received more than 500 citations in the last decade. It was also found that there are much more articles published on the risk management area than in the others, showing this results that the area is of high interest for the research.

Figure 41 shows the author's visualization of the most cited papers (Figure 41 (a)), the top connected articles (Figure 41 (b)) based on citations, and the density of connected

articles (Figure 41 (c)) in the field of the current study. VOSviewer analysis revealed that just 5 documents out of 90 were linked based on citations. In terms of citations, the not close proximity of the articles reflects that they are not highly related. Moreover, the density visualization confirms this current situation of the document's co-citations.

N/A	Document	Title	Year	Citations	Total link
1	Fernandes D.(Fernandes et al., 2014)	Financial literacy, financial education, and downstream financial behaviors	2014	757	0
2	Bryde, D.(Bryde et al., 2013)	The project benefits of building information modelling (BIM)	2013	728	1
3	Kou, G.(Kou et al., 2014)	Evaluation of clustering algorithms for financial risk analysis using MCDM methods	2014	588	0
4	Mangla, S.K.(Mangla et al., 2015)	Risk analysis in green supply chain using fuzzy AHP approach: A case study	2015	316	0
5	Basher S.A. (Basher & Sadorsky, 2016)	Hedging emerging market stock prices with oil, gold, VIX, and bonds: A comparison between DCC, ADCC and GO-GARCH	2016	285	5
6	Meng X.(Meng, 2012)	The effect of relationship management on project performance in construction	2012	280	0
7	Škare M.(Škare et al., 2021)	Impact of COVID-19 on the travel and tourism industry	2021	265	0
8	Mazzucato M.(Mazzucato & Semieniuk, 2018)	Financing renewable energy: Who is financing what and why it matters	2018	257	10
9	Cui C.(Cui et al., 2018)	Review of studies on the public–private partnerships (PPP) for infrastructure projects	2018	248	2
10	Taroun A.(Taroun, 2014)	Towards a better modelling and assessment of construction risk: Insights from a literature review	2014	239	0

11	Aminbakhsh, S. (Aminbakhsh et al., 2013)	Safety risk assessment using analytic hierarchy process (AHP) during planning and budgeting of construction projects	2013	238	0
12	Ferrer, R.(Ferrer et al., 2018)	Time and frequency dynamics of connectedness between renewable energy stocks and crude oil prices	2018	223	2
13	Shahriar, A.(Shahriar et al., 2012)	Risk analysis for oil & gas pipelines: A sustainability assessment approach using fuzzy based bow-tie analysis	2012	223	0
14	Lin W.-Y.(Lin et al., 2012)	Machine learning in financial crisis prediction: A survey	2012	200	0
15	Göçken M..(Göçken et al., 2016)	Integrating metaheuristics and Artificial Neural Networks for improved stock price prediction	2016	190	0
16	Wen X.(Wen et al., 2012)	Measuring contagion between energy market and stock market during financial crisis: A copula approach	2012	179	2
17	Lee S.-K.(S.-K. Lee et al., 2014)	BIM and ontology-based approach for building cost estimation	2014	177	0
18	Bynum, P. (Bynum et al., 2013)	Building information modeling in support of sustainable design and construction	2013	174	0
19	Jiménez G. (Jiménez et al., 2017)	Macroprudential policy, countercyclical bank capital buffers, and credit supply: Evidence from the spanish dynamic provisioning experiments	2017	171	0
20	Klingebiel R.(Klingebiel & Rammer, 2014)	Resource allocation strategy for innovation portfolio management	2014	170	0

Table 14 – Top 20 articles by VOSviewer with highest citations in the research of finance of projects

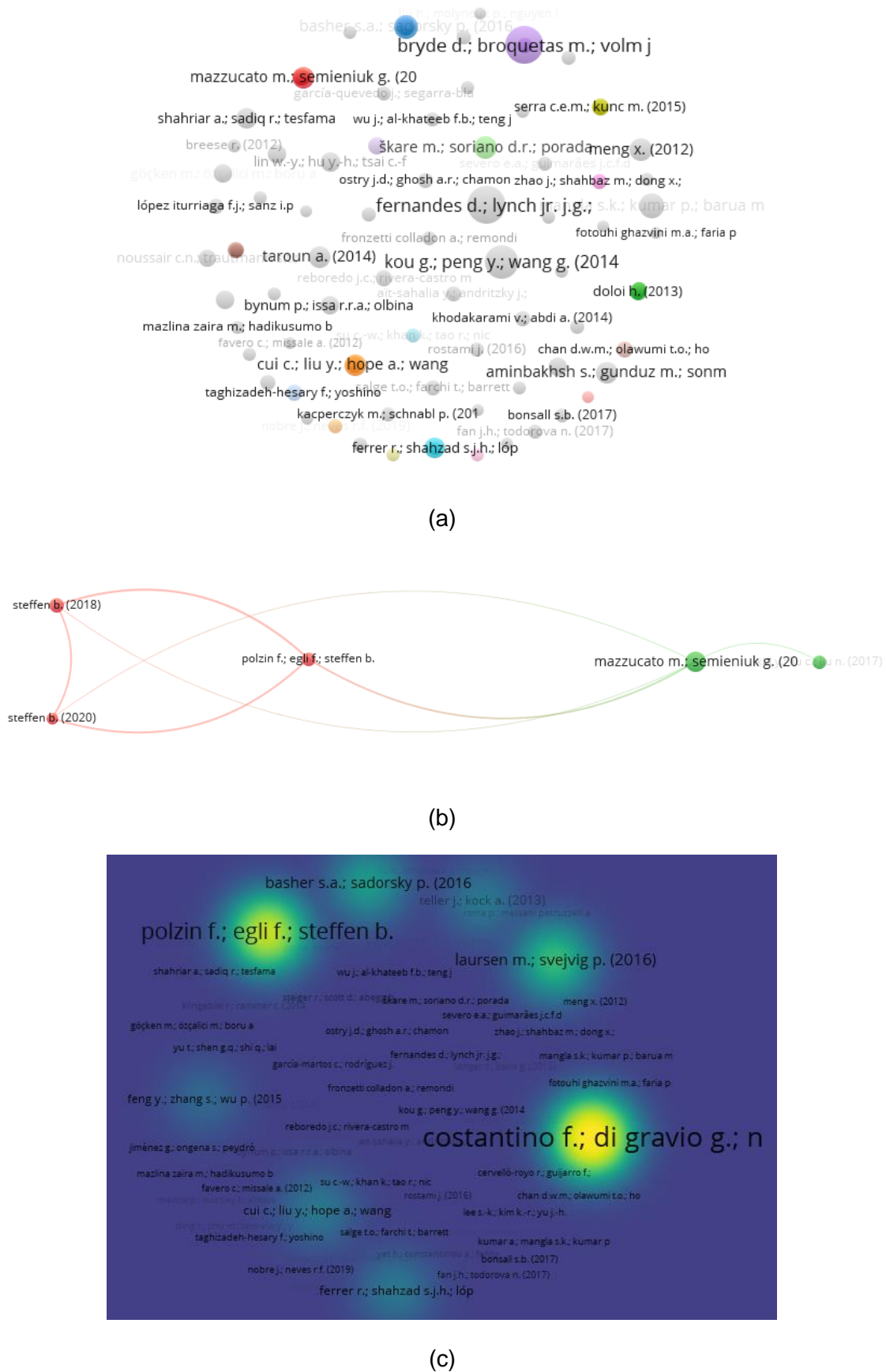


Figure 41 – Article's science mapping: (a) Visualization of articles with minimum 80 citations (b) Visualization of connected articles (c) Density of articles (Source: VOSviewer)

In addition, the citation overview that Scopus provides based on the 2000 first results is added to the results obtained with VOSviewer for the last 3 and 5 years, with 1101 and 1502 documents as a result for each year respectively, is made attending also to the citations. The h-index for the most relevant documents in the field for the last 3 years is of 31, and for 5 years is of 54. This means that from the considered documents, 31 and 54 of them have been cited at least 31 and 54 times respectively. In Table 15 and Table 16 the documents with at least 80 citations, the same parameter fixed for the study for the VOSviewer, are shown for 3 and 5 years respectively. For 5 years the most cited 20 documents are shown as more than 20 where meeting the 80 minimum citations set parameter.

N/A	Document	Title	Year	Citations
1	Škare M.(Škare et al., 2021)	Impact of COVID-19 on the travel and tourism industry	2021	265
2	Taghizadeh-Hesary F.(Taghizadeh-Hesary & Yoshino, 2020)	Sustainable solutions for green financing and investment in renewable energy projects	2020	135
3	Zhao J.(Zhao et al., 2021)	How does financial risk affect global CO2 emissions? The role of technological innovation	2021	122
4	Steffen B.(Steffen, 2020)	Estimating the cost of capital for renewable energy projects	2020	94
5	Elghaish F.(Elghaish et al., 2020)	Integrated project delivery with blockchain: An automated financial system	2020	85
6	Kumar A.(Kumar et al., 2021)	Mitigate risks in perishable food supply chains: Learning from COVID-19	2021	81

Table 15 – Articles with at least 80 citations by Scopus for the last 3 years

N/A	Document	Title	Year	Citations
1	Škare M.(Škare et al., 2021)	Impact of COVID-19 on the travel and tourism industry	2021	265
2	Jiménez G.(Jiménez et al., 2017)	Macroprudential policy, countercyclical bank capital buffers, and credit supply: Evidence from the spanish dynamic provisioning experiments	2017	171
3	Steiger R.(Steiger et al., 2019)	A critical review of climate change risk for ski tourism	2019	164

4	Steiger R.(Steiger et al., 2019)	Project governance, benefit management, and project success: Towards a framework for supporting organizational strategy implementation	2017	150
5	Chan D.W.M.(Chan et al., 2019)	Perceived benefits of and barriers to Building Information Modelling (BIM) implementation in construction: The case of Hong Kong	2019	137
6	Taghizadeh-Hesary F.(Taghizadeh-Hesary & Yoshino, 2020)	Sustainable solutions for green financing and investment in renewable energy projects	2020	135
7	Zhao J.(Zhao et al., 2021)	How does financial risk affect global CO2 emissions? The role of technological innovation	2021	122
8	Polzin F(Polzin et al., 2019)	How do policies mobilize private finance for renewable energy? A systematic review with an investor perspective	2019	121
9	Roma,P.(Roma et al., 2017)	From the crowd to the market: The role of reward-based crowdfunding performance in attracting professional investors	2017	112
10	Xia, Y.(Xia et al., 2017)	Cost-sensitive boosted tree for loan evaluation in peer-to-peer lending	2017	110
11	Bonsall, S.B.(Bonsall et al., 2017)	Managerial ability and credit risk assessment	2017	106
12	Severo, E.A.(Severo et al., 2017)	Cleaner production and environmental management as sustainable product innovation antecedents: A survey in Brazilian industries	2017	105
13	Fronzetti Colladon A.(Fronzetti Colladon & Remondi, 2017)	Using social network analysis to prevent money laundering	2017	105
14	Su C.-W.(C.-W. Su et al., 2019)	Does geopolitical risk strengthen or depress oil prices and financial	2019	104

		liquidity? Evidence from Saudi Arabia		
15	Nobre, J.(Nobre & Neves, 2019)	Combining Principal Component Analysis, Discrete Wavelet Transform and XGBoost to trade in the financial markets	2019	103
16	Fan, J.H.(Fan & Todorova, 2017)	Dynamics of China's carbon prices in the pilot trading phase	2017	103
17	Almahdi, S.(Almahdi & Yang, 2017)	An adaptive portfolio trading system: A risk-return portfolio optimization using recurrent reinforcement learning with expected maximum drawdown	2017	97
18	Mensi, W.(Mensi et al., 2017)	Dynamic risk spillovers between gold, oil prices and conventional, sustainability and Islamic equity aggregates and sectors with portfolio implications	2017	97
19	Steffen B.(Steffen, 2020)	Estimating the cost of capital for renewable energy projects	2020	94
20	Yu, T.(T. Yu et al., 2017)	Managing social risks at the housing demolition stage of urban redevelopment projects: A stakeholder-oriented study using social network analysis	2017	94

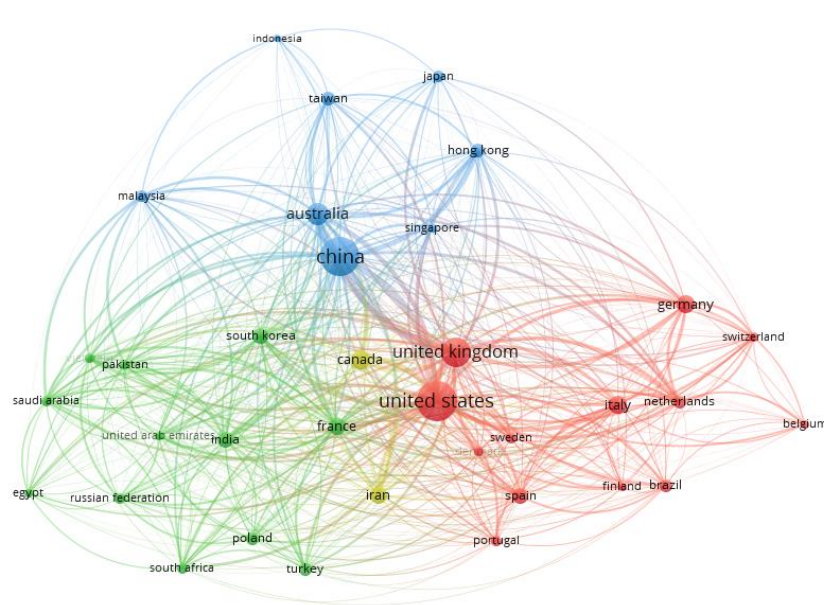
Table 16 – Articles with at least 80 citations by Scopus for the last 5 years

4.2.6 Top contributing countries

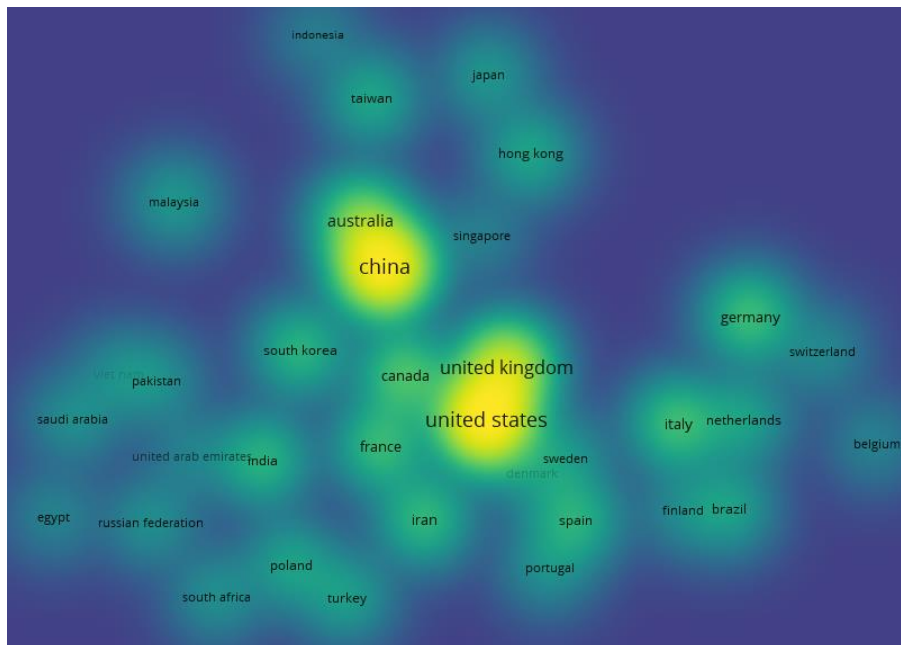
Certain countries have made and continue to make bigger contributions to the current research domain than others (Ahmad et al., 2021). "Bibliographic coupling" was chosen as the "kind of analysis", and "countries" as the "unit of analysis". A country's minimum quantity of papers was set at 20, and 35 of the 112 countries met this condition. Table 17 shows which 20 countries are the most active in terms of the number of publications and citations connected to the present research topic. United States, China and the United Kingdoms provided the most documents, with 527, 498 and 286 documents, respectively. These countries also received the most citations for their publications, with the United States at the top with 9623, then China with 7097, and after that United Kingdom with 6835 citations.

The total number of documents, citations, and connections demonstrates the impact of a country on the present research field (Ahmad et al., 2021). The total link strength indicates how much a country's papers influenced the other countries. Once again,

United States has the strongest total link strength of 22595, followed by the China with 18708, and United Kingdom with 17999 total link strength. As a result, the mentioned countries were shown to have the largest influence on the finance of projects. The links and density of countries based on citations are depicted in Figure 42(a) and Figure 42 (b), respectively. The graphical representation and quantitative record of the participating nations will assist future researchers in the field in making scientific alliances, launching collaborative ventures, and exchanging creative methods and concepts (Khan et al., 2022).



(a)



(b)

Figure 42 – Top contributing countries mapping: (a) Network visualization (b) Density visualization (Source: VOSviewer)

N/A	Country	Documents	Citations	Total link strength
1	United States	527	9623	22595
2	China	498	7097	18708
3	United Kingdom	286	6835	17999
4	Australia	159	3069	11567
5	Canada	125	2387	6956
6	Italy	110	2066	4971
7	Germany	109	2759	4950
8	France	102	2023	7840
9	Iran	96	1322	4537
10	South korea	89	1423	5764
11	India	87	1535	5815
12	Spain	82	3144	4441
13	Taiwan	66	1313	2554
14	Hong kong	64	1321	5256
15	Poland	59	845	2413
16	Brazil	59	1029	2017
17	Netherlands	59	2069	5393
18	Turkey	54	1336	2674
19	Malaysia	46	858	3541
20	Japan	45	631	1593

Table 17 – Top 20 most contributing countries in the research of finance of projects

4.2.7 Financing within the scientific bibliography

Financing is a very general term which covers so many different areas not only within projects, but within all the different types of sectors for the professional world, for the familiar areas, etc. After performing a scientometric analysis over scientific bibliography retrieved from the Scopus database on finance of projects, the clearest active research sectors were found to be the renewable energy and construction sectors. The other research areas, either studied for the last decade, last 5 years and last 3 years are not clearly defined areas. This study performed a review of the data founded with the scientometric analysis, so that the trends where mapped, focusing on the documents that cover the field of projects from a project manager point of view.

4.2.7.1 Renewable energy

Due to the climatic emergency current situation that the world is facing, changes like the European Green Deal (*Un Pacto Verde Europeo, s. f.*) that transform the countries all over the world into climatically neutral countries are needed. Sustainable Development Goals (SDGs) and the Paris Agreement for climate change (*Taghizadeh-Hesary & Yoshino, 2020*) are other goals established by the governments regarding climate change. One of the measures to be implemented is cleaner energy and forefront clean technological innovation. Within this measure is where renewable energy is categorized. One of the key points in the transition into this low emission energies is the ability to

obtain enough finance to steer investment in renewable energy (RE) (Mazzucato & Semieniuk, 2018). (Taghizadeh-Hesary & Yoshino, 2020) quoted that “the future of clean energy no longer concerns science and technology; it is all about access to finance” (Donovan, 2015; Taghizadeh-Hesary & Yoshino, 2020).

Green energy projects are large and long-term projects which need of high investments because they are considered infrastructural projects (Taghizadeh-Hesary & Yoshino, 2020). Two are the main characteristics of these types of projects, which are also barriers at the same time, a lower rate of return and a higher risk of investment compared to fossil fuel projects. The fact that the renewable energy projects have a higher risk than the fossil fuel projects make it difficult for banks to invest in this type of project. But this is not the only reason, the risks are spread among consumers and the uncertainty of the prices for the high speed of the technology evolving makes it difficult to access finance (Taghizadeh-Hesary & Yoshino, 2020).

The large upfront investment required in the RE needs to be made efficiently from a cost point of view. For this purpose, the cost of capital (calculated as discount rate) is an important part of the lifecycle costs of RE projects, which is a mixed of the social and private cost of capital (Steffen, 2020). For the appraisal of this type of projects anyway, the private cost of capital, more known as just cost of capital is the one that matters the most (Steffen, 2020). A methodology for this calculation was developed by (Steffen, 2020) in his paper, even though it was based on assumptions and therefore, with limitations due to the confidential nature of the renewable energy sector.

Trying to access to other types of non-banking finance could be a solution, financial institutions for example. (Taghizadeh-Hesary & Yoshino, 2020) anyway, developed a method for the financial institutions of reducing risks in green financing called green credit guarantee schemes (GCGSs) along with the measures adopted by the banks of having specific programs for a precautionary approach to green lending, as well as compliance and risk management. GCGS would reduce the asymmetry of information and decrease the expected default losses. Furthermore, a way of increasing the rate of return could be the usage of spill overs effects of the projects (Taghizadeh-Hesary & Yoshino, 2020).

On the other hand, financial actors investing portfolios influence in the direction that the technology follows. The risk direction is also another factor, where different trends between the public and private finances can be found, the former tending to higher risks than the latter. Mazzucato and Semieniuk (Mazzucato & Semieniuk, 2018) found through the research conducted within BNEF data from 2004 to 2014, that emphasis should move from the total amount of finance to its composition, what lead to implications for the policies to be established from a financing point of view.

The results obtained by (Mazzucato & Semieniuk, 2018) reported that each type of finance determines the direction of the technology. In this way, the policies adopted need to take care of favoring financial actors, since they will have their priorities. When developing a policy for a determined technology, the knowledge about the heterogeneity in financial actors benefits the policy. Historical trends about the financing adopted previously are also helpful. Attention not only to the upstream phase of the project or technology should be paid, but also to the downstream phase. The coordination of

different types of financing within the deployment phase needs to be attended. Finally, to just consider the types of finance from a private or public view is not deepen enough. It is important to consider the characteristics of the financial actors. To take care of the development of the policies will be useful to avoid later problems, preventing surprises and lock-ins.

4.2.7.2 Construction

Construction projects have largely turned out to be much more difficult to manage due to the high number of parameters that the project managers need to take into account. In the last years, the researchers have been focused on the investigation of the available tools for the managing of aspects like risk or the whole project management.

With the introduction of Building Information Models (BIM) project managers were not only provided a way of managing the building in 3D as well as the input of information, but they were also provided with project management tools and processes through the entire life cycle of the project (*Bryde et al., 2013*). Moreover, the 5D BIM is known as a traditional 3D BIM with scheduling information (the 4th D) and information for estimating the project from the model (the 5th D) (*Bryde et al., 2013*). Cost reduction is likely to be one of the positive effects arising from the use of BIM, either focused on a phase or in the whole construction cost. The risk management is also improved, even though a negative effect could appear due to the upfront investment for the modelling of the project to win the bid (*Bryde et al., 2013*).

The reduction in cost is due to that the software can facilitate effective site planning to enhance efficiency as well as reduce the rework to save time and money (*Aibinu & Venkatesh, 2014; Al Hattab & Hamzeh, 2015; Azhar, 2011; Chan et al., 2019; Fazli et al., 2014; Masood et al., 2014; Wc, s. f.; Wong et al., 2009; Yan & Demian, 2008*) for the construction, even though the most interesting plan for the financing is that a better cost estimation could be done. BIM can generate some data including the quantities of materials automatically increasing the accuracy of the cost estimate (*Azhar, 2011; Dakhil & Alshawi, 2014; Fazli et al., 2014; Ku & Taiebat, 2011; G. Lee et al., 2012; Masood et al., 2014; Wong et al., 2009*). This estimation anyway needs to be supported by cost estimators, which provide a subjective view (*S.-K. Lee et al., 2014*) because even though theoretically all the needed information can be obtained from BIM, practically, unless all the information is included within BIM, help from the estimator is needed for searching for appropriate work items. The searching of these work items can be done by the engineers so that the cost estimation is more accurate with the use of ontological approach and semantic technology combined with BIM, which is more, makes it possible to automatize the cost estimation by automatizing the search of suitable work items for the building elements and materials (*S.-K. Lee et al., 2014*).

One of the best-known types of finances that could be analyzed through BIM models is the PPP partnership. This finance model allows for huge projects to go ahead. Through the years this type of financing has evolved until today, as investigated by (*Cui et al., 2018*). 6 are the main research topics in which the scientific community is focusing. From 1990 to 2000, the researchers attempted to summarize the main features of the PPP structure by analyzing the cost, concession, equity structure (*Cui et al., 2018; Tiong, 1995*), and contracts. From 2000 onwards the focus changed to detailed issues in the financial package. Several authors published different theories and measurement

methodologies, simplified model for build-operate-transfer (BOT) projects (*Bakatjan et al., 2003*), genetic algorithm (GA) based model (*N. Smith et al., 2004*), etc. The popularization of PPP finance models turned to be important. Nowadays, the term sustainability has become presented a simplified model, which combined a financial model and a linear programming model, to determine the optimum equity level for decision-makers at the evaluation stage of a BOT project.

(*Cui et al., 2018*) found that the economic viability and value for money (VFM) are some of the most relevant topics that nowadays are also closely investigated along with stakeholders' satisfaction, and the economic environment. Many tools and techniques have been provided by the researchers through the last two decades, even though, over the past few years the focus of studies about a PPP's economic feasibility has shifted from the calculation of evaluation indices of traditional methods of economic feasibility assessment to the improvement of evaluation methods as well as the establishment of brand-new evaluation systems. (*Cui et al., 2018; Fantozzi et al., 2014*) developed and analyzed a public sector comparator (PSC), for which the valuation of risk, borrowing costs, and bid costs were established as the key parameters, which were taken from the ones that (*Cui et al., 2018; Heald, 2003; Pitt et al., 2006*) identified as key factors increasing VFM. However, the VFM assessment should be extended so that long-term social and sustainable impacts are considered. The evaluation of the stakeholder satisfaction from a financial perspective has been done through many methodologies, quantitative and qualitative approaches, stakeholder consultation and management responsibilities among critical stakeholders (*Cui et al., 2018; De Schepper et al., 2014; Henjewele et al., 2013; Sohail et al., 2004*), since the stakeholder satisfaction influences the suitability of a project for PPP as well as their collaboration and performance influences the application conditions.

Risks are also part of the PPP structures, being the ones that impact cost financing, construction, and operation cost overruns (*Cui et al., 2018; Ibrahim et al., 2006*). Risk cannot be ignored, they can be minimized, shared, transferred or accepted (*Taroun, 2014*). Successful PPP imply unique strategies and capabilities in risk management (*Cui et al., 2018; Tiong, 1995*). Public and private should be assessed separately due to the complex nature of risks. Risk register matrix, a fuzzy synthetic evaluation approach (*Cui et al., 2018; Effah Ameyaw & Chan, 2013; Xu et al., 2010*) or Monte-Carlo approach (*Alonso-Conde et al., 2007; Chang & Ko, 2017; Cui et al., 2018; Wibowo & Alfen, 2013*) are some of the tools for the risk assessing. In a general terms, not only for PPP, the Probability–Impact (P–I) risk model is prevailing and risk is usually assessed through assessing its probability of occurrence and impact (*Taroun, 2014*).

The P-I model has been proposed to be enhanced several times by adding new measurement parameters that allow for evaluating beyond the variances the traditional model of variances of costs or duration. More measurements that are capable of reflecting the true nature of the risk and the experience of the management team in handling risk, the complexity of project systems that may affect risk assessment and the interaction between project risks are proposed by (*Taroun, 2014*).

On the other hand, the allocation of the risks between public and private is considered as one of the principal factors in evaluating and creating VFM. (*Alonso-Conde et al., 2007; Cui et al., 2018*) introduced the so called “real-options” for this evaluation. A correct

allocation of the risks is included among the critical success factors (CFS). Many groupings and definitions of key terms have been done, but finally, (Chou & Pramudawardhani, 2015; Cui et al., 2018) set up five groups, stable macroeconomic environment, shared responsibility between public and private sectors, transparent and efficient procurement process, stable political and social environment, and judicious government control.

When speaking about construction project risks assessment (Taroun, 2014), like in any other type of project, subjectivity is present due to the perception of risk and the probability parameter included in the assessment. In addition, within the construction, the experience and judgment of the individuals are the basis for risk assessment. As this subjectivity cannot be removed, FST was introduced as a viable alternative for handling subjectivity in construction risk assessment. Complexity in the projects is also present and cannot be avoided, and so because of that, AHP was introduced providing a systematic approach to structuring risk assessment problems by providing a logical approach for assessing risk impacts and allocating importance weighting. Furthermore, sophisticated DSSs are being devised to facilitate the analytical and statistical tools and to handle the growing complexity of risk assessment. This more realistic assessment allows for an also realistic project risk level determination against the current limitations.

Whereas the tools exist, there is still a lack of agreement for a common scale of measuring risk impacts. Yet risk cost is being used as a risk measurement impact scale, the output remains to be the sum for covering the risk instead of being the risk impact on project objectives, what could provide far from the actual methods, a quantitative evaluation. The risk has turned from being considered as an estimation variant towards as a project attribute.

Financing is a very concerning topic within the construction sector due to the complexity of this type of projects. (Baker et al., 1998; Taroun, 2014) found that for financial risk assessing expected money value (EVM) was the main tool along with break-even, scenario and sensitivity analysis not only in the construction, but also in the Oil and Gas industries, supporting the intuition, experience, and the judgment of the individuals. On the other hand, risk management is believed to benefit particularly in project budgeting and contingency estimation.

4.2.7.3 Financing related tools from several sectors

Risks are uncertainties associated with any form of financing (Kou et al., 2014). Many types of analysis could be done for analyzing the financial data in search of risks in advance like the methods found for construction or business intelligence (Gennari et al., 1989; Kou et al., 2014). These analysis also help to minimize the defaults, and to support better decision making (Kou et al., 2014), 'risk' is the cornerstone in decision making process (Shahriar et al., 2012).

In a more general manner, it can be said that between the supervised and unsupervised analysis methods, the unsupervised methods bring the opportunity to find underlying structures in unlabeled data while providing labelled data for supervised methods (Kou et al., 2014). Clustering algorithms is one of the most used unsupervised methods. MCDM was proposed by Rokach (Kou et al., 2014; Rokach, 2010) as a way of evaluating

clustering algorithms, a difficult task since the lack of objective measures (Kou et al., 2014).

The clustering algorithms provide solutions that then need to be evaluated using performance indicators. (Kou et al., 2014) carried out an analysis for 3 financial risk data with 6 different clustering analysis, which were afterwards measured through 11 performance indicators. These indicators belonged to an internal and external collection, even though relative test is a third option of measurement, a more subjective method based on the needs of the user. Finally, 3 MCDM methods were used to rank the clustering algorithms. (Kou et al., 2014) found out that no algorithm can achieve the best performance on all measurements for any data set and it is necessary to utilize more than one single performance measure to evaluate clustering algorithms. However, the repeated-bisection algorithm provides the best solutions.

Another tool for risk assessment is presented by (Shahriar et al., 2012) based on Oil and Gas (O&G) pipelines. Pipelines all around the world have faced issues due to different problems, leading them to extensive maintenance supposing these sometimes-heavy financial liabilities. Though this issue is not exclusive to this industry but can happen in any. Fault tree analysis (FTA) and event tree analysis (ETA) are two graphical methods used to perform risk analysis. "Bow-tie" is an approach integrating both FTA and ETA to represent causes, threats, and consequences.

Every risk event is usually considered independently, but this is not a completely correct approach. Besides, within this type of assessment, the subjective part added to the fact that an individual is doing the assessment and probabilities are involved needs to be sorted out some way. Fuzzy Set Theory (FST) could be included to handle this aspect of the analysis (Shahriar et al., 2012). The aim is to be able to handle data and model uncertainties together, qualitative, and quantitative data. Once the likelihood of the risk is obtained by the FTA and ETA, the introduction of the utility value provides the way to evaluate the consequences of the corresponding risk. Using the fuzzy utility value (FUV), which includes fuzzy synthetic evaluation (FSE) and fuzzy rule based (FSB), the subjective part is also included. But what is more, the possible social, economic, and environmental consequences are also considered.

Evaluating financing includes not only evaluating risks, but predictive models for bankruptcy and credit soaring can be done by financial institutions for avoiding further financial issues. Machine learning is among some of the techniques that can be used for that purpose (Lin et al., 2012), like soft classification techniques. Stock market prices are another prediction to be done for a good financial evaluation since they are one of the most important indicators of a country's economic situation (Göçken et al., 2016; Perwej & Perwej, 2012). However, this type of analysis is far from being exact, following the nature of a prediction, they are also characterized by nonlinearities, discontinuities, and high frequency multi-polynomial components due to the high number of factors with which they interact. This predictions can be based in technical indicators such as simple moving average of close price, momentum close price, etc. (Göçken et al., 2016; Hadavandi et al., 2010). The relationship between the indicators and the stock prices can be done with models, among which Harmony Search (HS) based Artificial Neural Network (ANN) were found by (Göçken et al., 2016) to be the dominants, being also possible to build hybrid model using more than one model as investigated by (Göçken

et al., 2016). Within these types of models, the critical parameters are found to be by (*Göçken et al.*, 2016) the number of input variables and the number of neurons.

In addition, stock markets are highly influenced by the crude oil, a contagion phenomenon was found by (*Wen et al.*, 2012) although not the same countries followed the same pattern of relation. To be able to determine the contagion grade allows a better risk management and policy making (*Wen et al.*, 2012).

5 Methodology

So that these purposes defined in the scope are fulfilled, a methodology it's been followed considering each of the purposes as a step. But firstly, a methodology to select the topic and the goals for the study was followed.

5.1 Selection of the topic

The selection of the topic for the end master thesis is quite a difficult decision and therefore creativity is usually needed to be able to get to a specific topic. Creativity is not something spontaneous and it needs to be motivated with specific methodologies so that the issue faced is finally resolved. In this case, the process followed was done in a group of 4 people who exposed each of the possible topics to be selected for themselves. The steps followed were 4 of them, Figure 43.

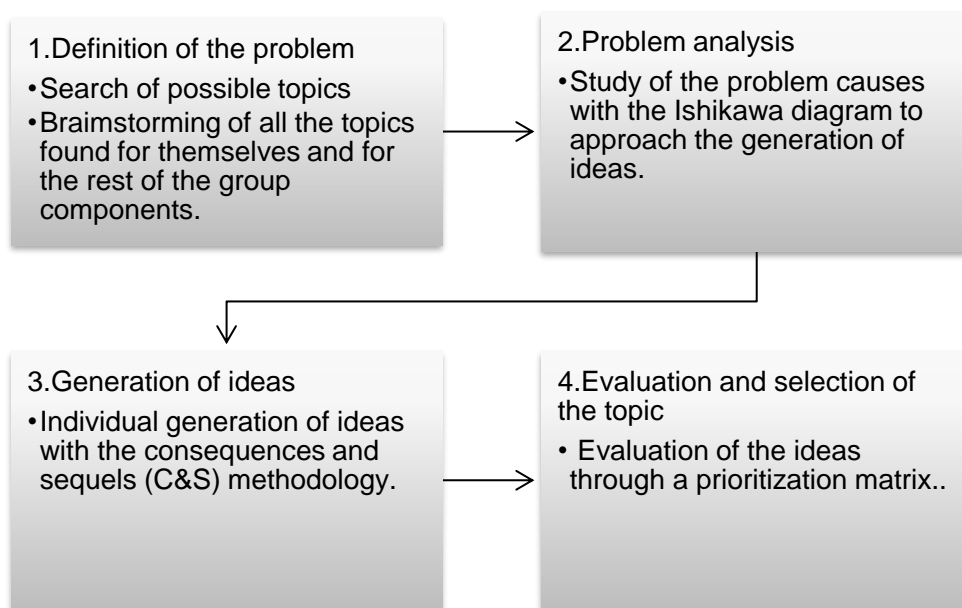


Figure 43 – Steps for carrying a creativity methodology

1. Definition of the problem

Each component of the group tries to find firstly possible topics by asking professors of subjects of interests through the master or inspiration on other universities databases containing completed end master thesis. Also, the other components of the group did provide possible topics by means of a brainstorm.

2. Problem analysis

The main reasons for such a difficulty while trying to find the topic are found to be the planification, specificity, information, author/person, and interest, Figure 44. Planning is a factor that interferes in the choice of the topic since it is essential to consider the method, resources, and time before choosing the topic. Specificity is a relevant factor since if it is a very specific topic there will not be much knowledge in the state of the art, and it can be an obstacle. However, if it is a very general topic, there may be a possible infoxication in the literature. Similarly, there may be a lack of guidance on

this factor. Perhaps one of the most important factors in choosing a topic is the information due to that the literature is essential. The bibliographic or expert search may be complex, or the vocabulary of that same literature may be very technical. The author/person is one of the main reasons why it is difficult to choose a topic either, because the author has lack of motivation, lack of knowledge or because of his lateral thinking. The last factor is the interest because the topics may not generate interest in the person who is going to develop them, or in the readers and for that same reason there is very little knowledge about the topic.

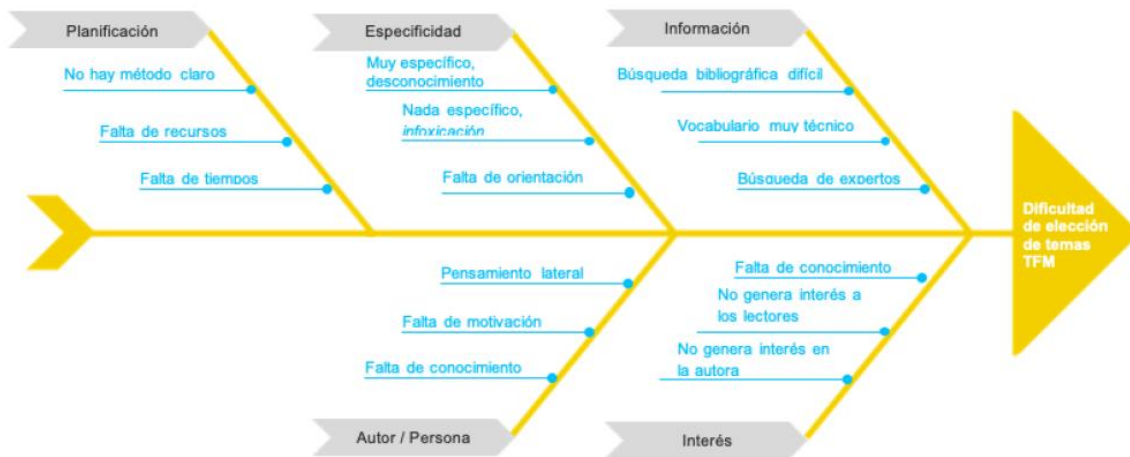


Figure 44 – Ishikawa diagram

3. Generation of ideas

FINANCIACIÓN

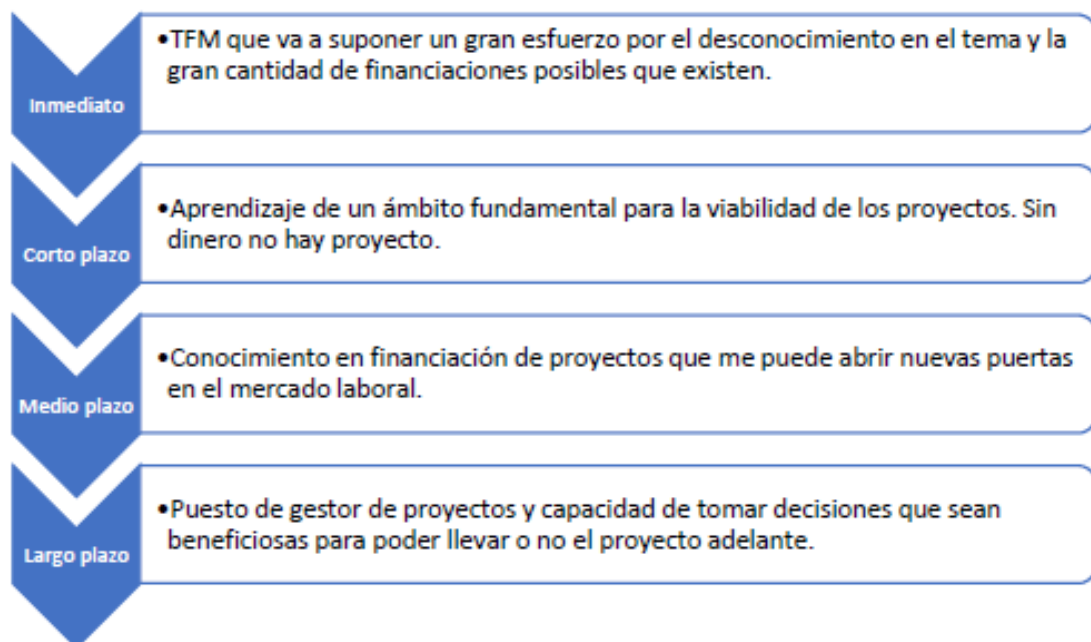


Figure 45 – Funding C&S

GESTIÓN DEL CAMBIO

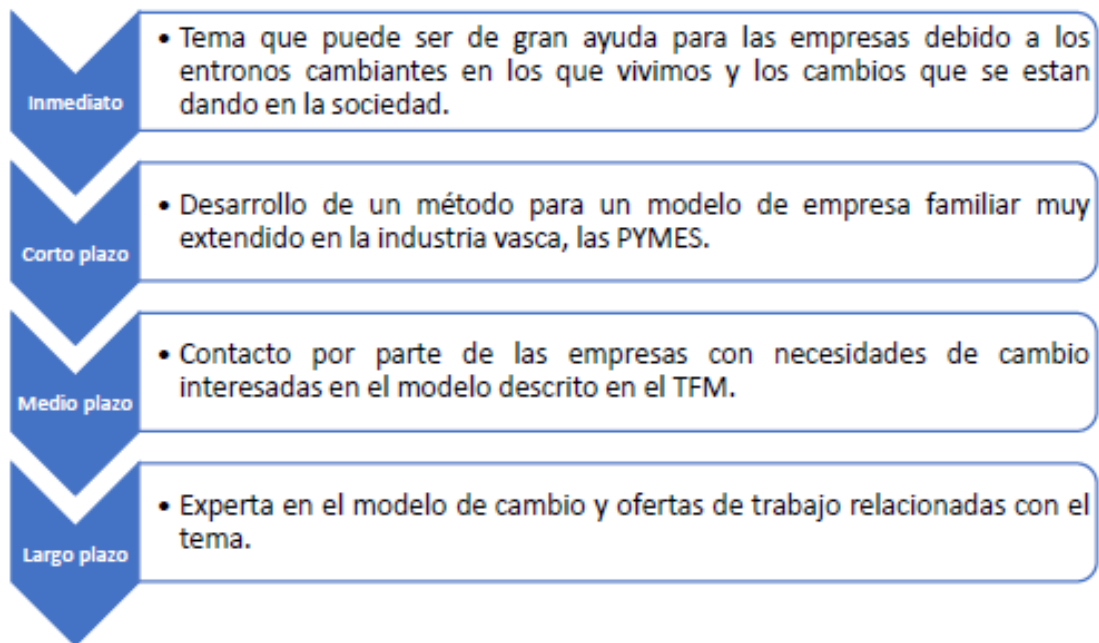


Figure 46 – Change management C&S

COMUNICACIÓN INTERCULTURAL

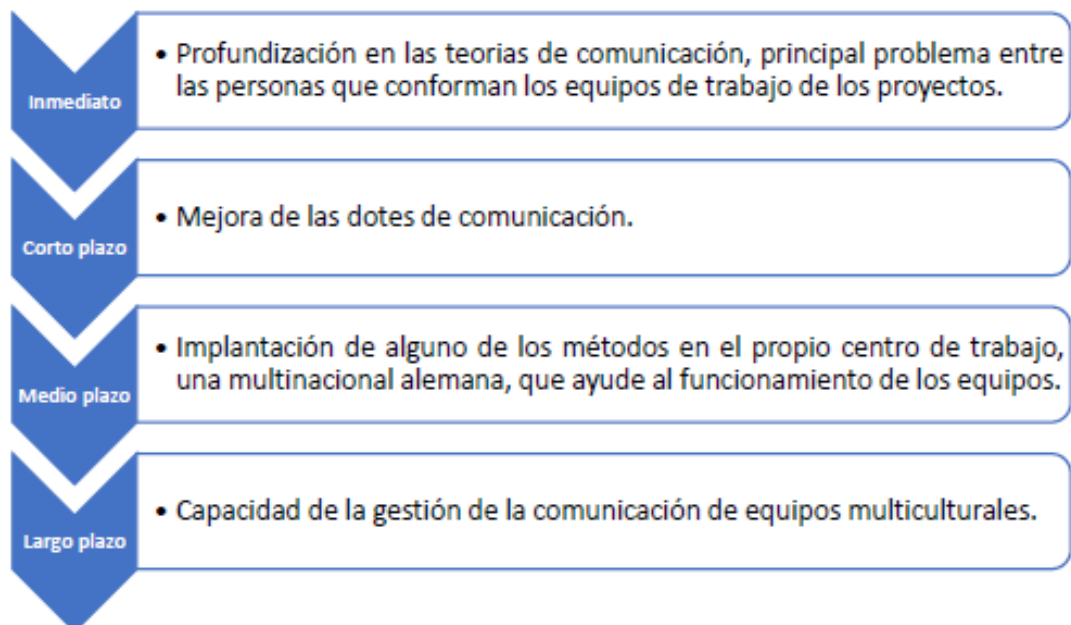


Figure 47 – Intercultural communication C&S

NEGOCIACIÓN

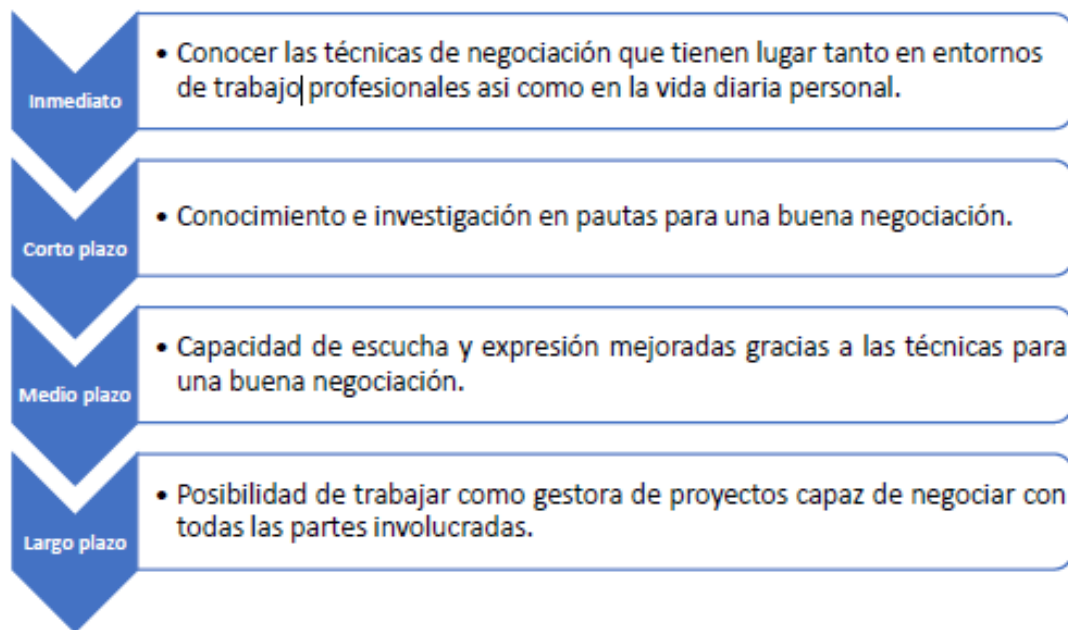


Figure 48 – Negotiation C&S

The C&S methodology consists of an activity in which to analyze the consequences and sequels of the possible topics. The consequences are those repercussions that the decisions may have immediately or in the short term, while the after-effects are those that would take place in the medium or long term. 4 areas are considered, funding, change management, intercultural communication and negotiation. From Figure 45 to Figure 48 included the C&S analysis are shown. For each area a possible topic to be developed was found.

➤ **Funding**

Treatment of project finance in all project management standards (PMBOK, ISO 21500:2021, PRINCE 2, IPMA NCB, etc.).

In this possible TFM topic we will delve into how the project management standards reflect the project financing guidelines. After this analysis, we will propose possible improvements that can be incorporated so that the standards are as practical as possible and serve as a guide to achieve the best financing structure that fits each specific project.

➤ **Change management**

Model of change for family businesses

In the proposed topic, after an analysis of the written bibliography about change management in work or professional environments, a change model will be written with guidelines for a possible success about change in family businesses. An attempt will be made to propose a change guide for this type of companies generally closed to old management models and that have a great resistance to adapt to the new

environments in which the companies find themselves, necessary changes to survive in time.

➤ **Intercultural communication**

Guidelines for efficient management and communication between intercultural teams located in different countries.

Nowadays the teams of workers are more and more extended by different spaces of the planet, and with the substantial increase of teleworking this has been accelerated. In this work we will try to write a guide with guidelines to facilitate the management of this type of multicultural teams in order to succeed in the project.

➤ **Negotiation**

Negotiation techniques in VUCA environments vs. environments with high job stability.

The business environments in which we move today lack stability that gives us fixed guidelines on how to deal with the most relevant issues on a daily basis. In this TFM we will try to delve into the negotiations and the theories written about them that allow us to write a series of guidelines and good practices that help to negotiate on a solid foundation to be successful in today's industrial environment.

4. Evaluation and selection of the topic

For the evaluation of the ideas 7 criteria were defined and an evaluation from 1 to 5 being 1 the lowest value was established. Each component established also the most valuable criteria for each self in case of doubt.

Criteria	
	1. Innovation in the area of study. If it represents an improvement within the chosen area of study.
	2. Focused on professional prospects. If it is in line with the student's professional projections.
	3. Achievable in the stipulated time. If it is possible to develop the work proposed in the time stipulated by the university and by the student.
	4. Focused on project management. If the scope of the chosen topic is focused on the use of any tool studied in the master's degree.
	5. Fits one of the 4 possible modalities. If the chosen topic can be focused on one of the 4 TFM modalities allowed by the School of Engineering of Bilbao.
	6. Possibility of broadening knowledge. It is also intended that the chosen topic provides extra knowledge to the student.
	7. Focused on the labor market. It is attractive for companies and can become a way to get a job, so it will also be taken into account when choosing the topic.

Figure 49 – Criteria

Evaluation value	Meaning
1	Strongly Disagree
2	Disagree
3	Indifferent
4	Agree
5	Strongly agree

Table 18 – Evaluation criteria

The result is shown in Figure 50. The evaluation of the topics was done by another component of the group for each. Despite of the fact that the most suitable topic seemed to be the one selected for the area of intercultural communication, all of them were quite similar and the results were tight. It was decided the topic related to the finance area due to the high interest on it nevertheless. The most important criteria were selected to be the possibility of broadening knowledge, for what all the topic were also suitable.

	Criterio 1	Criterio 2	Criterio 3	Criterio 4	Criterio 5	Criterio 6	Criterio 7	Puntuación total
Tratamiento de la financiación de proyectos en todos los estándares de Dirección de proyectos	5	3	3	4	4	5	5	
	87,5	52,5	30	40	40	87,5	87,5	425
Modelo de cambio para empresas familiares	4	3	5	4	4	5	5	
	70	52,5	50	40	40	87,5	87,5	427,5
Pautas para la gestión y comunicación eficiente entre equipos interculturales situados en diferentes países	4	5	5	4	3	5	5	
	70	87,5	50	40	30	87,5	87,5	452,5
Técnicas de negociación en entornos VUCA frente a entornos de gran estabilidad laboral	5	4	4	4	4	5	4	
	87,5	70	40	40	40	87,5	70	435

Figure 50 – Matrix results

5.2 Study the state of the art of the financing within the most relevant standards for project management

For the study of the standards the methodology followed is decided to focus on the most representative standards of project management. In this way, the PMBOK, IPMA and PRINCE are the some of the biggest associations within the area that provide their own standards. Additionally, the ISO21500:2012 is included as the IPMA refers to it by means of a comparison between them, and PM2 guide is also included.

After the project management methodology that each standard provides is understood, a brief review of the table of contents is done looking for the factors that affect the financing, the data that each standard provides on it is gathered in the study and classified. Finally, the financing information within each standard is compared between all of them by means of different aspects each of them in tables.

The Construction extension to the PMBOK Guide is studied along with the other 5 standards due to its financial management area. The comparison to the Construction extension is done separately as a conclusion once the standard is reviewed.

5.3 Review the bibliometric data related to finance of projects that researchers provided through the last decade (2012-2022)

So that the state of the art of the scientific data is properly done, it is decided to conduct for the topic a scientometric analysis. The main reason for choosing this analysis is that, as (Oliveira et al., 2019) wrote, “It is an essential element that provides researcher means to identify and support paths towards the development of scientific projects.” Nowadays, huge amounts of articles can be found through different scientific database platforms. To identify and analyze the scientific performance of articles, authors, etc., scientometric provides research with instruments. To be able to conduct this scientometric analysis, after the field of study was chosen based on the interest of the author for the topic, the steps described in Figure 51 are followed:

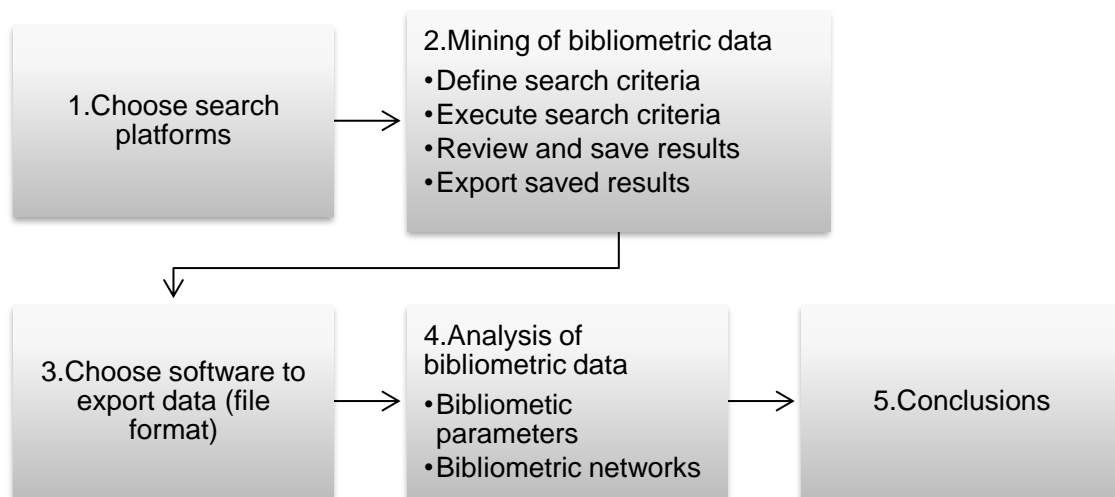


Figure 51 – Steps for carrying a scientometric analysis

1. Choose search platforms

“The choice of the scientific research platform is one of the actions that has a significant impact on the bibliometric analysis and, therefore, must be well planned in order to obtain assertive results and avoid reworking.” (Oliveira et al., 2019). The platforms provide different tools between them so that the best fitting one should be selected, for what comparisons are done attending to the same parameters for each of them. Many databases can be found for accessing scientific data. (The Best Academic Research Databases [2022 Update], 2022) provides 8 of them. Three of them are discarded due to that the discipline is not within the area studied, Table 19. Between the other 5 resources a comparison attending to 3 parameters is done in Table 20.

Resource	Approx. items	References	Discipline
PubMed	30 million	NA	Medicine, Biological
Eric	1.3 million	NA	Education
IEEX Xplore	5 million	NA	Engineering

Table 19 – Academic resources not multidisciplinary (Source. (The Best Academic Research Databases [2022 Update], 2022)

Resource	Approx. items	References	Discipline
Scopus	71 million	1.4 billion	Multidisciplinary
Web of science	100 million	1.4 billion	Multidisciplinary
ScienceDirect	16 million	NA	Multidisciplinary
Directory of Open Access Journals (DOAJ)	4.3 million	NA	Multidisciplinary
JSTOR	12 million	NA	Multidisciplinary

Table 20 – Academic resources comparison (Source. (The Best Academic Research Databases [2022 Update], 2022))

In addition, the last years some more bibliographic databases have appeared, which are in according to (Visser *et al.*, 2021) Dimensions, Crossref, and Microsoft Academic, who also provides a comparison of these three databases against Scopus and Web of Science attending to the coverage of documents. Google Scholar, as well as OpenCitation, are not included in the comparison even if they are important data sources too, either because large-scale studies of Google Scholar (Martín-Martín *et al.*, 2018, 2021; Visser *et al.*, 2021) require an extraordinary amount of effort (Else, 2018; Visser *et al.*, 2021), or because OpenCitation currently provides more or less the same data as Crossref (Heibi *et al.*, 2019; Visser *et al.*, 2021).

(Visser *et al.*, 2021) found that all the databases suffer from problems of incompleteness and inaccuracy of citation links, even if the most established data sources Scopus and WoS are a better alternative in this way than Dimensions and Microsoft Academic, for which missing citation links are a significant problem. In Crossref, incompleteness of citation links is a major problem. On the other hand, Dimensions and Microsoft Academic do offer comprehensiveness covering a wide range of documents, whilst selectivity is offered by Scopus and WoS with a more restricted universe of documents (Visser *et al.*, 2021). For this study the selectiveness of Scopus and WoS is preferred.

Using two platforms could result in a more consistent bibliometric analysis, although it can result in a difficult integration of the data between the different structures of the platforms. Attending to the documents covering studied by (Visser *et al.*, 2021) between the years 2008 and 2017, Scopus is selected.

2. Mining of bibliometric data

The selected keywords for the mining of bibliometric data were “finance of projects”, “project cost estimation”, “financial risk assessment”, “project benefit management” and “project investment appraisal”. Only the “article” and “review” were selected from the “document type” drop-down menu, and only “journal” and “review” were chosen as the “source type” as these are the most reliable sources since they are peer-reviewed in their full version (Garza-Reyes, 2015; Oliveira et al., 2019). “English” was chosen for the “language” along with the limiting of the “publication year” from 2012 to 2022. Finally, the “subject area” of “engineering”, “businesses, management, and accounting” and “economics, econometrics and finance” were chosen and the “publication stage” was set to “final” along with excluding “project finance” from the keywords. A summary of the search criteria defined is shown in Figure 52.

Defined search criteria	Database: Scopus
	Publication period: 2012-2022
	Document type: Articles and reviews
	Source type: Journals
	Subject area: Engineering; businesses, management and accounting; economics, econometrics and finance
	Language: English

Figure 52 - Defined search criteria

Scopus provides various bibliometric data from which the researcher must choose which needs to be exported into the software to be analyzed. (Oliveira et al., 2019), Figure 53. The remaining data after applying the filters was exported from Scopus in the corresponding format for analysis with a suitable software tool.

<input checked="" type="checkbox"/> Citation information	<input checked="" type="checkbox"/> Bibliographical information	<input checked="" type="checkbox"/> Abstract & keywords	<input type="checkbox"/> Funding details	<input checked="" type="checkbox"/> Other information
<input checked="" type="checkbox"/> Author(s)	<input type="checkbox"/> Affiliations	<input checked="" type="checkbox"/> Abstract	<input type="checkbox"/> Number	<input type="checkbox"/> Tradenames & manufacturers
<input checked="" type="checkbox"/> Document title	<input type="checkbox"/> Serial identifiers (e.g. ISSN)	<input checked="" type="checkbox"/> Author keywords	<input type="checkbox"/> Acronym	<input type="checkbox"/> Accession numbers & chemicals
<input checked="" type="checkbox"/> Year	<input type="checkbox"/> PubMed ID	<input type="checkbox"/> Indexed keywords	<input type="checkbox"/> Sponsor	<input type="checkbox"/> Conference information
<input type="checkbox"/> EID	<input type="checkbox"/> Publisher		<input type="checkbox"/> Funding text	<input checked="" type="checkbox"/> Include reference
<input checked="" type="checkbox"/> Source title	<input type="checkbox"/> Editor(s)			
<input type="checkbox"/> Volume, issues, pages	<input checked="" type="checkbox"/> Language of original document			
<input checked="" type="checkbox"/> Citation count	<input type="checkbox"/> Correspondence address			
<input checked="" type="checkbox"/> Source & document type	<input type="checkbox"/> Abbreviated source title			
<input checked="" type="checkbox"/> Publication stage				
<input type="checkbox"/> DOI				
<input type="checkbox"/> Open access				

Figure 53 – Bibliometric data to be exported from Scopus

Additionally, Scopus provides the option to analyze the results obtained. The data extracted from this option is used to analyze the trend of each keyword over the last decade plus the total documents for all the keywords added to the search in a single search.

3. Choose software to export data

A review done by (Moral-Muñoz et al., 2020) analyzed various software that could be used for bibliometric analysis and also for science mapping analysis (SMA). The SMA is an enhanced analysis from just a bibliometric analysis in which the relationship among the different actors (Moral-Muñoz et al., 2020) is shown. The software and some of their characteristics are shown in Figure 54.

Tools	Analyzed version	Year	Developer	Operative System	User Interface
Bibexcel	2017	2017	University of Umeå (Sweden)	Win	Desktop
Biblioshiny		2019	University of Naples Federico II (Italy)	Runs in R	Web
BiblioMaps	3.2	2018	University of Lyon (France)	Runs in Python	Web
CiteSpace	5.5.R2	2019	Drexel University (USA)	Win	Desktop
CitNetExplorer	1.0.0	2014	Leiden University (The Netherlands)	Win, OSX, Linux	Desktop
SciMAT	1.1.04	2016	University of Granada (Spain)	Win, OSX, Linux	Desktop
Sci² Tool	1.3	2018	Cyberinfrastructure for Network Science Center (USA)	Win, OSX, Linux	Desktop
VOSviewer	1.6.13	2019	Leiden University (The Netherlands)	Win, OSX, Linux	Desktop

Figure 54 - Characteristics of the SMA tools (Source: (Moral-Muñoz et al., 2020))

Between the 8 software, SCIMAT has great preprocessing and exporting capabilities, offering the widest type of tasks compared to the other software with a great visualization through the strategic diagram and thematic areas (Moral-Muñoz et al., 2020), Figure 55. VOSviewer has a not-so-great preprocessing capabilities, even though it contains a great visualization (Moral-Muñoz et al., 2020). Both of them are compatible with Scopus database (Moral-Muñoz et al., 2020). The chosen software for the analysis is VOSviewer since it was found to be easy to use and the laptop used for the development of the study was compatible with it while SCIMAT was not working constantly. Whatsoever, VOSviewer is a highly recommended software (Oliveira et al., 2019). Scopus tools for analyzing results and citation overview were also used for the postprocessing of the results.

Tools	Duplicate documents	Plurals / Singulars	String distance	De-duplication*	Time slice	Stop words	Data edition**	Filters
General bibliometric and performance analysis								
CRExplorer								X
ScientoPyUI	X							X
Science mapping analysis tools								
Bibexcel	X							
BiblioShiny					X			X
BiblioMaps					X			X
CiteSpace					X			X
CitNetExplorer								X
SciMAT		X	X	X	X	X	X	X
Sci² Tool	X	X (stemming)			X	X		X
VOSviewer								X

Figure 55 - Preprocessing of the SMA tools (Source: (Moral-Muñoz et al., 2020))

4. Analysis of bibliometric data

Among the different bibliometric parameters that could be chosen to analyze, following the scientometric analysis done by (Ahmad et al., 2021; Khan et al., 2022) and the guidelines exposed by (Oliveira et al., 2019), the bibliometric parameters to be analyzed are decided to be “annual publication trend”, “top publication sources”, “most used keywords”, “most cited articles”, “most cited authors” and “most productive journals”. The bibliometric type of analysis for the generation of the networks that were used for the scientometric analysis are the bibliographic coupling, co-occurrence and co-citation with different units depending on the analysis to be done.

VOSviewer was used to import the Scopus CSV (Comma separated values) file to analyze it in a few simple steps while maintaining data consistency and reliability additionally to the Scopus tools analyze results and citation overview. After creating the networks, the data is reviewed for duplicities in an exported txt file from VOSviewer with the help of Excel application.

Within the bibliographic coupling, co-occurrence, and co-citation networks, as part of the science mapping review, the sources of articles, the most frequently occurring keywords, the most cited authors and articles, and the region’s participation were analyzed. Maps were used to illustrate the various parameters, their relationships, and co-occurrence, which were shown with different formats and tables summarizing their numerical values were added. For the author’s analysis, the h-index calculated by Scopus for each author was added.

Finally, for the most cited articles analysis, three different types of analysis based on the h-index number by Scopus were added. All the documents found were sent to the citation overview tab, where all the documents allowed by Scopus for analysis were added. This was repeated for the las 3 and 5 years, and then tables summarizing the obtained documents were added as well as their h-index parameter was recorded.

5. Conclusions

For the conclusion, the abstract and conclusions of the most relevant documents are reviewed, and from them, the information related to the topic is extracted. For the analysis, two main areas are identified according to the trends shown by the scientometric analysis, the renewable energy sector, and the construction. The rest of the researchers are gathered in a more general group. The articles that have been further analyzed are shown in Table 21.

N/A	Document title
1	The project benefits of building information modelling (BIM)
2	Evaluation of clustering algorithms for financial risk analysis using MCDM
3	Financing renewable energy: Who is financing what and why it matters
4	Review of studies on the public–private partnerships (PPP) for infrastructure
5	Towards a better modelling and assessment of construction risk: Insights from a literature review
6	Risk analysis for oil & gas pipelines: A sustainability assessment approach using fuzzy based bow-tie analysis

7	Machine learning in financial crisis prediction: A survey
8	Integrating metaheuristics and Artificial Neural Networks for improved stock price prediction
9	Measuring contagion between energy market and stock market during financial crisis: A copula approach
10	BIM and ontology-based approach for building cost estimation
11	Sustainable solutions for green financing and investment in renewable energy projects
12	Estimating the cost of capital for renewable energy projects

Table 21 – Analyzed documents

5.4 Proposal of a new finance process for project management

For the proposal of a new finance process the methodology described in Figure 56 is followed.

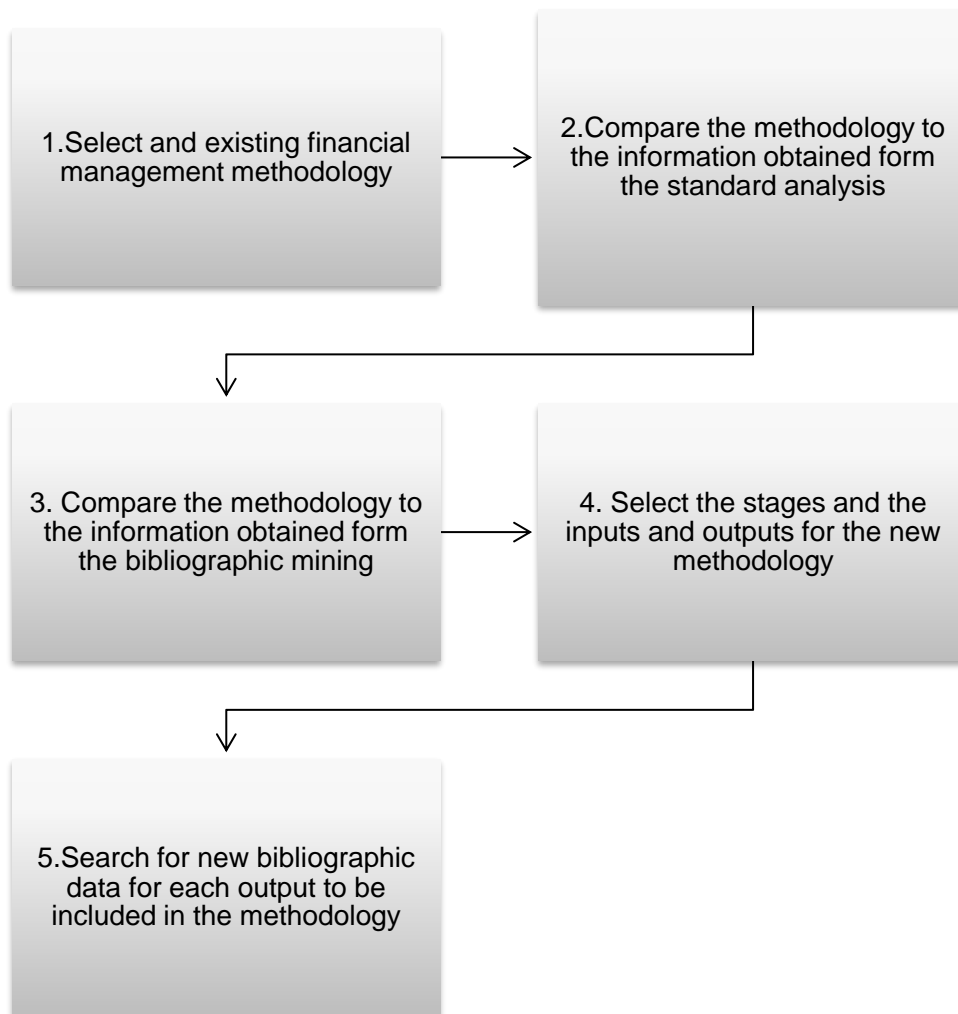


Figure 56 – Proposal of new finance processes methodology

6 Results

The results obtained by conducting the investigation of the available literature for the finance of projects for the project manager can be divided into three obtained results with regards to the analysis of the overall project management standards PMBOK Guide Seventh Edition, IPMA ICB 4.0, ISO21500:2012, PM2 guide and PRINCE 2 training manual. Secondly, the analysis of the Construction Extension to the PMBOK® Guide, and finally, the results obtained from the analysis of the scientific bibliography data done with scientometric review.

6.1 PMBOK Guide Seventh Edition, IPMA ICB 4.0, ISO21500:2012, PM2 guide and PRINCE 2 training manual

The PMBOK Guide Seventh Edition provides within the system for value delivery 1 function associated with project referring to funding, "Provide business direction and insight" by means of the supportive role of a project manager when shortage of funding happens. The standard also finds 2 external factors affecting the funding, the commercial databases containing cost estimating data and the financial considerations including currency exchange rates, interest rates, inflation, taxes, and tariffs. 8 out of 12 principles were found to be related in some way to finance. Some of them are included by means of responsibility like "Be a diligent, respectful, and caring steward" due to the caring aspect of the role regarding finance, or by means of costs and benefits, "Effectively engage with stakeholders", while the business case is mentioned within the "Focus on value" principle.

Changes are always present in a project, and they do affect many aspects of it if not all. In this way, towards funding "Recognize, evaluate, and respond to system interactions" refers to changes in a project that lead to changes in monetary terms. "Demonstrate leadership behavior" principle includes skills to lead with seeking resources, while "Navigate complexity" introduces the difficulties at any point of the project and the need to deal with them. "Optimize risk responses" adds responses for a cost-effective answer to risks, even if they are threats or opportunities, though the life cycle of the project. The two last principles that are related to the funding are "Tailor based on context" and "Build quality into processes and deliverables", that enables an effective project plan to adjust to the cost and enhances cost control by using quality management respectively.

6 performance domains out of 8 were providing some insight mainly for 3 factors, which are, costs, risks, and control. "Development Approach and Life Cycle" points out that the development approach chosen needs of the funding input to be correctly selected, like the decisions towards the product and the investment. "Planning" refers to cost's estimations and budgets and provides types of estimations that can be done. "Project work performance domain" gives guide to decide where to spend the fundings best. "Delivery performance domain" refers to the business case, the basis of the funding. It gives knowledge of the content that the documents should have.

"Measurement performance domain" provides three indicators for the controlling of the costs that are AC, CV and CPI among many others like ROI or NPV. Finally, "Uncertainty performance domain" states that the funding is another aspect of a project contributing to uncertainty.

Finally, 2 models, 19 methods and 4 artifacts along the whole life cycle of the project for different stages could be used for the developing of finance activities within the tools and techniques like thinking strategies, a business case or a SWOT. PMBOK covers all through the complete standards, mainly costs and risks related factors, followed by budgeting. Theoretical aspects to consider for a financing planning are stated, but no clear guidelines are provided to be followed. The models, methods and artifacts are how to knowledge, while the functions, factors, principles, and performance domains are what to knowledge.

IPMA ICB 4.0 includes a competence within the practice area specifically for finance. The standard finds the finance structure as one of the responsibilities of a project manager even though the accountability can be in charge of the financing department. This finance (practice 7) is related to all the other 12 practice competences, as well as to 2 perspective competences and 4 people competences for the project management as they are interrelated and interact between them. Some of the relationships with the competences were found to be:

- *Design (Practice 1)*: Definition of the approach of the project in which high level decisions are taken being the funding one of them.
- *Requirements and objectives (Practice 2)*: Benefits mapping by aligning with the stakeholder.
- *Scope (Practice 3)*: Costs are included on each task of the project, which is then used to control the budget.
- *Resources (Practice 9)*: Includes the financial constraints.
- *Procurement (Practice 9)*: Sharing of funds can be added in the procurement route chosen.
- *Plan and control (Practice 10)*: Monitoring processes gathering information to compare with baseline.
- *Risk and opportunity (Practice 11)*: Deals with contingency plans, expected monetary value and sensitivity analysis regarding risks and opportunities.

As for the aspects introduced by the Finance (practice 7) competence, it deals with the inflows and outflows of the project, cost management (outflow often related to a budget) and finance or funding respectively, where the funding is seen as the inflow internal to the organization and the finance as the inflow external to the organization. Guides for a financial approach for a project are provided from the planning of the financial to the controlling of the plan. Indeed, 5 competence key indicators that can be taken as steps for the financial planning are provided, starting from the cost's estimations, which are then allocated on each of the tasks to be done, to finally monitor them through a CBS implementing corrective actions if necessary. The cost estimation includes all types of costs that are present in a project, for which top-down or bottom-up calculations can be done. All of these tasks should be done based on an already established system in the organization that needs to be known by the project manager in order to apply for, justify, manage and report successfully the finance of the project. 15 knowledge inputs and 14 skill and abilities related to the Finance (Practice 7) competence that shall be acquired by a project manager for a proper financial management are provided. On the other hand, a comparison to the ISO21500:2012 in terms of correspondence of processes

included within the standard to the finance (practice 7) competence is given by IPMA ICB 4.0.

ISO21500:2012 includes the financial aspects for the value creating by means of projects so that the organization can achieve the strategy. The standard refers to the business case as the document where the information needed for the investment decisions by appraisal techniques appears. Costs and budget are among the constraints of a project to which the deliverables are related, despite that they are not the only one related to finance as the acceptable risk exposure and the applicable laws, rules and other legislative requirements are also included by the standard.

The ISO21500:2012 finds that the finance discipline shall be supported by the support process, which is not included, yet this process interacts with the ones that are covered by the standard. Each of the process groups defined by ISO21500:2012 is related somehow to the rest. Two subject groups are related to the financing within 3 process groups, cost, and risk. Cost subject group includes processes for the establishing of the budget, controlling of the costs and completion of the project within the expected budget, whereas risk subject group includes processes to maximize the success against opportunities and threats. In total, 7 processes are provided with regards to the field of research, for which primary inputs and outputs are included, even though this standard is also a what to standard, not adding how to develop the tasks. Attending to each process found to be related to the finance, these are the relationships (inputs and outputs are also included for each of them within the standard):

- *Estimate costs*: The goal is to obtain an approximation of the costs of all the resources that will be used in the project. Details such as units, exchange rates, expected fluctuations, reserve contingencies, etc. are mentioned.
- *Develop budget*: It deals with the allocations of costs for each task. Cost estimation relates to the total amount of money while budgeting refers to the money available for each task.
- *Control costs*: Gathers the information for monitoring cost variances and therefore the information to apply corrective actions. It is closely related to the control changes management system.
- *Identify risks*: The aim of this process is to determine the positive and negative risks and opportunities in a project and their characteristics.
- *Assess risks*: The aim of this process is to measure and prioritize the positive and negative risks and opportunities in a project for the preparation of further action with regards them.
- *Treat risks*: The aim of this process is to manage the positive and negative risks and opportunities in a project by developing actions to enhance the opportunities and reduce the threats.
- *Control risks*: The purpose of this process is the minimized disruption of the negative effects on the project related to the threats.

Another process could be added to the already mentioned ones, that is 4.3.2 Develop project charter process as this process introduces the business plan along with the statement of work. The business case for the ISO21500:2012 includes the justification, needs, objectives, expected results, economic aspects, and alignment with the strategy of the project. It is an alive document through all the life cycle. The standard also brings

the project charter and the project management plan as inputs for the project plan document.

PM2 guide links the financial aspects to the project portfolio management as it does see the allocation of the monetary resources as a whole including all the project related to the achievement of the strategic goals of the organization. Therefore, they are not directly related to the project management. The governance layer, once decided the investment, releases the funding. The business case is the responsibility of the directing layer, while the project manager oversees the day-to-day work.

Attending the stages of a project provided by the standard, the financial aspects are decided in 2 of them, the initiating and planning phases, even though changes can occur at any moment. In the initiating phase, the ones involved define the objectives, ensure the alignment, decide the approach of the project development, and gather all the necessary information in the project initiation request, business case and project charter documents for the planning stage once they client request is received. In the planning stage, the project plan document is developed with the overall information of the project with regards to the scope, approach, schedule, cost estimation and detail of project plans.

PM2 guide has mindsets included in it defining them as the glue that holds the processes and practices together. Among the questions to be asked to oneself to be sure of the correct ongoing of the project, the balance between the cost and risks acquired for the success of the project should be ensured. The standard does also provide matrixes where the roles are defined for each of the outputs of every stage by means of accountable, responsible, supporter, consulted and informed. The documents related to the finance on the initiating and planning phases for which this information is given are the project initiation request, business case, project charter and project work plan. During the executing phase, the project ongoing is monitored for the PM2 guide and the documents that reflect the gathered information are the project progress and status reports, including on them financial information. The roles are also provided.

During all the project life cycle, the monitoring and controlling activities are present for the PM2 guide. Among those activities, some of them are linked to the finance aspects. 6 out of 13 have some relation with the cost and risk controlling at list, which eventually affects the decision-making process. The following activities and the respective relation are as follow:

- Monitor project performance: Cost and risk are tracked by the PM forecasting the evolution.
- Control cost: The budget is tracked and compared to the baseline by the PM. The PSC is informed in case it is at risk for corrective actions. The overruns are reported and approved by the PO or the AGB.
- Manage project change: The corrective actions are assessed.
- Manage risk: Negative risks are managed to avoid cost overruns.
- Manage issues and decisions: Negative issues are managed to avoid cost overruns.
- Manage business implementation: The business activities are controlled so that the budget is followed.

Finally, the PM2 guide includes in the standard templates and tools and techniques related to financial management. 5 templates were found to be useful, whether 6 tools and techniques are highly related to the activity of financing.

PRINCE2 training manual, the last standard to be studied regarding project management, differentiates the monetary benefits from other type of benefits that a project is expected to return, relating the cost variables to the ones giving a return on the investment done. Furthermore, the manual is not detailing specialist aspects such as how to structure a financial project organization yet one of the benefits of applying the method ensures that the project viability is continuously assessed from a business case point of view. It also provides templates and detailed content for documents like business cases or project plans.

The business case, the justification for the project development, is part of the responsibilities of the executive in the initiation stage, even though the project manager can support on the duty as well as a financial department worker. It is also updated in the controlling stage. The responsibilities towards the business case are present in the PRINCE2 training manual for each of the 5 roles specified in a project, as well as many needed skills are mentioned. The document is also detailed in the theme dedicated to it within the PRINCE2 training manual, mainly answering three questions through a structure that is also reflected on the standard.

1. Why the project?
2. What are the business reasons?
3. What are the benefits achieved for the organization?

Based on the project mandate, it shall include guidelines, reasons, justification, and the possibility of achievement for the project. This is shown by also the estimate costs and timescale, benefits and dis-benefits and an overview of the risks. PRINCE2 training manual exposes 5 types of business cases depending on the project, and also provides 4 steps for the creation. From the initiation stage information on the project mandate, cost, timescale, product, risk register and project brief are obtained. Then the type of business case is selected, and finally, the outline and the detailed business case are developed. The document is validated several times during the project, and updated usually at the end of each stage, yet 7 points are considered validation key points by the standard.

The benefits are treated once the project is over in the benefits review document, and the plan theme answers how much will be necessary to produce the product cost. The progress theme covers the control of the project to ensure the viability against the business case. When assessing risks, they are estimated and evaluated, and the results of these actions could be a risk budget which cannot be used for anything else.

Regarding the comparative between standards, all of them do provide some insight into the financial management, even though the only standard that includes it clearly is the IPMA ICB 4.0. PMBOK Guide Seventh Edition does also give much information on the field, but it is spread through the whole standard with references from practically all the areas covered. The ISO21500:2012 is the standard with the less information on finance of projects. Moreover, the PM2 guide links the financial management to the project portfolio management at a very high level unlinking it from the project management role.

Finally, PRINCE2 training manual states that it is very general not providing detailed specialist aspects such as how to structure a financial project organization yet one of the benefits of applying the method ensures that the project viability is continuously assessed.

The five standards do have a different structure. However, IPMA ICB 4.0 is the only one not directly addressing the standard for project managers, as it does also not define the role and responsibilities supposed for the role. Relations to other performance domains and principles, to other competencies within other domains, and to other processes are given in PMBOK Guide Seventh Edition, IPMA ICB 4.0 and ISO21500:2012 respectively. PM2 guide and PRINCE2 training manual also include relations between activities as inputs and outputs and principles and the variables are included on each step where necessary respectively. Just PMOK Guide Seventh Edition and PM2 guide include the how-to information apart from what to.

6.2 Construction Extension to the PMBOK Guide

The Construction Extension to the PMBOK Guide includes not just the supposed general responsibilities for a project manager, but 4 financial management responsibilities areas are pointed out. Accounting for financial resources of the project, managing costs and profits, managing cash flows, and finally, deciding or providing the information for decision making. The finance of a construction project is more focused on the revenue than on the day-to-day costs, where the finance mainly comes from private sources. The requirements of any type of project shall be addressed in the contract agreed between the owner of the project and the contractor. 3 major processes are included within the financial management area, planning, control, and administration and records. For each process, also called stages in this document, inputs, outputs, and tools and techniques are provided.

In the planning the project requirements, roles and responsibilities, tasks and resources are set. 8 inputs, 5 tools and techniques, and 3 outputs are given. Finance is usually a mix of money coming from different sources, either public or private. The public sources will ask for detailed information before granting the money like scope, schedule, budget, objectives, benefits and return on investment, correlation to the business strategy, project management ability and milestones that are achievable. The private funding refers to the project creditworthiness and the sensitivity to interest rates. 11 common sources are included in the standard, while 5 methods to confront fluctuations that can come from external factors such as the economic environment are provided.

The risks shall be allocated to avoid overruns, but this is just one of the many aspects affecting the funding. Additionally, the deductible interest taxes and the usually non-deductible dividends to shareholders are to be taken into account. The project financial plan document is to gather all the financial requirements like the ones mentioned.

The monitoring and control ensure the effective execution of the financial plan. 4 inputs, 3 tools and techniques, and 1 output are given by The Construction Extension to the PMBOK Guide. On the other hand, besides the reports, audits and experts' advice such as legal advisors can be also added into the project. Finally, in the last stage of administration and records, 3 inputs, 3 tools and techniques, and 2 outputs are provided by the standard to be able to close the financial management related to the project.

Compared to the PMBOK Guide Seventh Edition, IPMA ICB 4.0, ISO21500:2012, PM2 guide and PRINCE2 training manual standards, just the IPMA ICB 4.0 provides as mentioned before a competence focusing on the finance as the Construction Extension to the PMBOK Guide. Anyway, the Construction Extension to the PMBOK Guide does include many best practices for the financial management that the other studied standards do not include even though the PMBOK Guide Seventh Edition, IPMA ICB 4.0 and PM2 guide do cover many financial factors and aspects. As the Construction Extension to the PMBOK Guide is based on the later version six of the PMBOK Guide, processes with inputs, tools and techniques, and outputs are included, what differs from the standards PMBOK Guide Seventh Edition, IPMA ICB 4.0, and ISO21500:2012, PM2 guide and PRINCE2 training manual, except that the ISO21500:2012 does provide processes too. Nevertheless, just both standards belonging to PMBOK are the ones that include the how to plus the what to for the field of research development.

6.3 Scientometric review of the scientific bibliography

This systematic review performed a statistical analysis and a mapping of the bibliographic data available in the research of financing of projects. This analysis identified the sources of publications (journals) that published the most documents, the most often-used keywords in publications, the documents and researchers with the highest citations, and the nations vigorously engaged in finance of projects research.

According to the assessment of keywords, risk management has mostly been researched to avoid further financial issues while the project is happening. For example, in the renewable energies sectors, which are currently in progression due to the climatic change, where the accessing of finance is not so easy due to the long-term returns and high risks included in the projects, a proper risk management before granting finance from the banks is one of the measures proposed by the authors. Moreover, the renewable energy sector was found to be in addition to the construction sector the clearest active research sectors for the searches done for the last 5 and 3 years.

The future of the RE is found to be based on the finance instead of in the technology by (Donovan, 2015; Taghizadeh-Hesary & Yoshino, 2020), being those project large and long-term projects needed of high investment. The main characteristics are found to be at the same time barriers, low rate of return and high risk of investment compared to fossil fuel projects. An efficient calculation of the cost of capital, which is a mix of social and private cost of capital, is basic, even though the private cost of capital is the most important for the appraisal. Financial institutions are another possible source of capital. Methods for reducing risks such as GCGSs have been developed along with specific measures adopted by banks. Some more factors like the actors investing on portfolios or the risk direction influence the project, but from a technological point of view. The emphasis should be moved from the total amount of finance to its composition (Mazzucato & Semieniuk, 2018).

When selecting a policy, which affects the technological direction too, the knowledge about heterogeneity in financial actors benefits the project as well as the historical trends. On the other hand, attention to the upstream and downstream phases should be paid too. In the deployment, attention to the all the different types of financing should be paid.

Regarding the construction projects, they are difficult due to the high number of parameters that need to be controlled. The research done the last years have been focused on the tools to help the project managers. BIM is one the most important tools that covers the project through its entire life cycle. Manages the building in 3D, the input of information, schedules the information or helps to estimate the project from the model helping to reduce the total cost or the risk management. Effective site planning, automatically quantities of materials or reducing the rework helps to save money and time. Anyway, cost estimators shall provide support giving subjective view.

BIM helps for the analysis of one of the most used financing models, PPP. Through the years, this type of model has been studied starting from the structure, continuing with detailed issues in the financial packages, theories like BOT or GA, and nowadays, the focus is on sustainability. This type of model is a combination of a financial model and a linear programming model. Economic viability and VFM are some other highly studied topics along with stakeholders' satisfaction, through quantitative or qualitative approaches, stakeholder consultation or management responsibilities among critical stakeholders, and the economic environment. PSC plus the VFM assessment is used as evaluation systems with the valuation of risks, borrowing costs and bid costs as main parameters.

Risk also impacts PPP structures by means of cost financing, construction, and operation cost overruns. Private and public must be assessed separately, for which risk register matrix, a fuzzy synthetic evaluation or Monte Carlo approach can be used. The P-I risk model is prevailing anyway, and more parameters than the traditional ones can be added for evaluation. The allocation of risk between public and private is one of the principal factors in VFM as the correct allocation is considered one of the main keys for successful management of risks. Yet a subjective approach is always present like the experience and judgement of the individuals involved. FST was introduced as an alternative for their handling, while AHP was introduced for the complexity management along with DSSs. The impacts are better assessed, a lack of agreement is anyway present in the measuring of them. Some other sectors like Oil and Gas were found to be using EVM as their main tool along with the scenario and sensitivity analysis supporting the subjective part.

In the rest of the sector research, the risks are a high concern too. Supervised and unsupervised methods are used for the assessment being the cluster algorithm (MCDM) being the most unsupervised used method. Additionally, to the method, performance indicators must be used. FTA and ETA are among the most used risk assessment methodologies within the Oil and Gas industry, and bow-tie combines both. The subjective part is also present in these methods, and therefore, FST is used to make a better approach. But not only the risks are evaluated in this way, including also the possible social, economic, and environmental consequences.

On the other hand, predictive models to avoid bankruptcy, stock market prediction or credit soaring can be done by financial institutions, like machine learning or soft techniques. Models like HS or ANN are among many others that can be used for these purposes. Finally, the crude oil price contagious the prices of the stock market, and the contagion grade can be determined.

In addition, the literature and their linkages based on citations were used to identify the highly committed and participating nations based on publication count. The graphical representation and quantitative analysis of the participating countries and researchers will help young scientists in forming scientific partnerships, establishing joint ventures, and sharing advanced methods and concepts. Scholars from countries concerned with expanding the research on the finance of projects can collaborate with professionals in the discipline and benefit from their expertise. After assessing keywords in the subject topic using the scientometric analysis method and reviewing the most relevant literature, this study highlighted and discussed the present-state applications of tools and techniques of finance of projects and the limitations associated with the risks inherent to some projects.

7 Conclusions

This study's purpose was to undertake a bibliographic analysis of the main standards that serve as guidelines for the project management while complementing it with a standard for the construction sector. Besides, a scientometric assessment of the available literature for the last decade (2012-2022) on finance of projects research to evaluate the current state of the scientific investigations and the latest progresses in the field was done. The database Scopus was searched for 2559 related articles and reviews, and the records were evaluated employing the VOSviewer application. The following conclusions were obtained:

- PMBOK Guide Seventh Edition provides information through the functions, performance domains and principles, as well as methods and artifacts linking them to the performance domains where they can be used, for various factors like costs, risks, taxes, and control related to the financing activity, even though clear guidelines are not provided.
- IPMA ICB 4.0 covers financing through the competence domain within the area practice, Finance (practice 7). The competence is also related in the standard to other competences which with it interacts, that are located within the practice, perspective, and people areas. Knowledge, skills and abilities, key competence indicators and measures for the development of the activity are provided.
- ISO21500:2012 does not provide a subject group or process that is focused on finance. Processes for costs and risks factors are included in the standard within the planning, implementing, and controlling process groups. Primary inputs and outputs are also available for each process.
- PM2 guide unlinks the financial management from the project manager role, even though covers the documents related to the funding decisions by means of when they are supposed to be developed and by whom. In the monitoring and controlling stage activities related to finance are given, apart from tools and techniques with templates.
- PRINCE2 training manual does not provide detailed specialist aspects even though the method helps to keep the project within the business case, document very detailed in the standard and which is part of the executive responsibilities unlinking it from the project manager role. References to risks and benefits management are also provided.
- Just only the IPMA ICB 4.0 includes the activity of finance as an entity, although it does not provide the project manager with tools or techniques to be used for the development. PMBOK Guide Seventh Edition and ISO21500:2012 covers some of the aspects that affect and are intrinsic to the finance of projects, even though it does not do it in a clear manner with guidelines to be followed. Methods and artifacts that could help in the construction of a finance plan are given but one more time, they are not provided clearly related to the activity. ISO21500:2012 provides just two groups of processes clearly related to the finance of projects with inputs and outputs, but no guidelines for how to develop those inputs and outputs for each process are given. PM2 guide serves the project manager with inputs and outputs that are related to the finance even though the standard finds out that the financial management is not part of the duties of the role. PRINCE2 training manual provides a very detailed description

of the business case document, but once again, the standard unlinks the duty of the development of the business case and the financial part of the project from the project manager role. IPMA ICB 4.0, ISO21500:2012 and PRINCE2 training manual are what to guides, while PMBOK Guide Seventh Edition and PM2 guide are a what and how to guide.

- The Construction Extension to the PMBOK Guide provides a complete financial management methodology, that with some adaptations adding tools and techniques provided by other standards for some aspects depending on the type of project to be developed, can be extended into any other sector, and used it as guideline for the financing of projects.
- An evaluation of publication journals, including articles and reviews on financing of project research, revealed that “Energy economics”, “Journal of construction engineering and management”, and “International journal of project management” are the top three sources, with 106, 79, and 74 publications, respectively. In terms of total citations, the top three publishing sources are “International journal of project management” with 4585, “Energy economics” with 3208, and “Journal of construction engineering and management” with 1926 citations.
- Assessment of keywords on the topic research field reveals that risk management, project management, risk assessment, financial risk, and risk are the five most often occurring terms. The keyword analysis found that risk management has mostly been researched to several sectors searching for tools and techniques to enhance the identification and assessment of them.
- Analysis of researchers found that just 6 authors had published at least 3 articles on finance of projects research. According to their document count, overall citations, and average citations, the leading authors were categorized. Lefley, F. is the most prolific researchers with 4 publications each, followed by Cheng, M.-Y., Tran, D.-H., Sousa, V., Almeida, N.M, and. Dias, L.A with 3. In terms of total citations, Sousa, V., Almeida, N.M, and. Dias, L.A. lead the field with 209, Cheng, M.-Y. AND Tran, D.-H. are second with 79, and Lefley, F. is third with 20 overall citations in the present research domain. In addition, when the average number of citations is compared, the authors might be ranked the same order as for the citations with 70, 26 and 5 average citations respectively.
- An assessment of published documents containing data on finance of projects for the last decade revealed that Fernandes D.(*Fernandes et al., 2014*)’s work “Financial literacy, financial education, and downstream financial behaviors” received 757 citations. Bryde, D.(*Bryde et al., 2013*) and Kou, G.(*Kou et al., 2014*) received 728 and 588 citations for their studies, respectively, and were among the top three. In addition, Škare M.(*Škare et al., 2021*)’s work “Impact of COVID-19 on the travel and tourism industry” received the most citations for the last three years, 265 exactly.
- Based on their engagement in finance of projects research, the top countries were evaluated, and it was concluded that only 35 countries published at least 20 documents. The United States, China, and United Kingdom presented 527, 498, and 286 documents, respectively. In addition, United States received 9623 citations, followed by China with 7097 citations, and the United Kingdom received 6835 citations.

- Since construction sector projects are large and long-term projects, their financing is a critical aspect of their success. These projects are turning more complicated while the time passes by, and therefore, researchers are very active in the investigation of the field regarding them. The overall managing of the project while with the introduction of BIM methodology has been improved, allowing it with the help of the ontological approach and semantic technology for a more exact cost analysis. PPP structures are some of the most widely used financed structures among the construction, for which various types of evaluation methodologies have been introduced in the last years like the VFM.
- Risk assessment is one of the main factors concerning financing within large investment projects in any sector. Many tools can be found for the assessing like Monte-Carlo approach or risk register matrix, being the probability impact (P-I) assessment the most used one. The decrease of the subjectivity factor and the allocation of the risks when managing them are some of the topics that still need to be improved, for which some techniques like FST and “real-options” respectively have been introduced the last decade. GCGS was a technique proposed for the renewable energy technique to reduce the risks in these types of projects attracting in this way banks to invest in the technology. MCDM for evaluation of clustering algorithm, or the “bow-tie” approach are other proposals coming from several sector for risks management.
- The Renewable energy is the future of the production or green energy for a sustainable world. Finance accessing is the main issue for the technologies due to the long-term return and high risks associate to the projects. Besides, financing actors influence in a high degree in the developing of the innovation, being possible to avoid it in grand manner with proper financing policies. The last years sector trends in financing and the characteristics of the financial actors should be included in the developing of the policies. The private cost of capital is another calculation to introduce when planning the financing for a cost-efficient project.
- Predictive models for evaluation of bankruptcy and credit soaring by financial institutions can be done by means of soft techniques within machine learning. Stock market prices predictions can be done due to that they show the economic state of a country with Harmony Search (HS) based Artificial Neural Network (ANN) that help to make them more accurate reducing the subjective part.

After project management standards review and a scientometric based review on finance of projects was done, it was noticed that the current state of research is not sufficient for a clear financial management process to be followed including the steps with the tools and techniques that a project manager of any type of project should followed. Based on the benefits of a proper finance decision based on a well-planned financial structure, it is recommended that a thorough investigation needs to be carried out for their practical applicability in any sector. A proposal for a financial management methodology is given based on all the information gathered so far.

7.1 Financial management methodology proposal for project managers

Many different financial management methodologies have been found through the literature review, but there is a lack of agreement referring to the steps to be followed to be able to develop a financial management plan. The stages for the financial management process could be the same as the ones described for a project, which are initiating, planning, implementing, monitoring, and closing, and that can also be connected between them as described in ISO21500:2012, Figure 12. Anyway, it is not a separate process but another competence of the project management to be developed within the project and therefore, a new methodology should be focusing on specifying the inputs and outputs towards the finance for each stage of the project already defined. Figure 57 shows the outputs for the initiating, planning, controlling stage, and finally the outputs for the closing stages of a project regarding the finance and funding of a project.

On the other side, it is important to keep on mind that from this point forward, the funding will be referring to the ability of an organization to finance the project with internal resources, while the finance refers to the ability of an organization to finance the project externally.

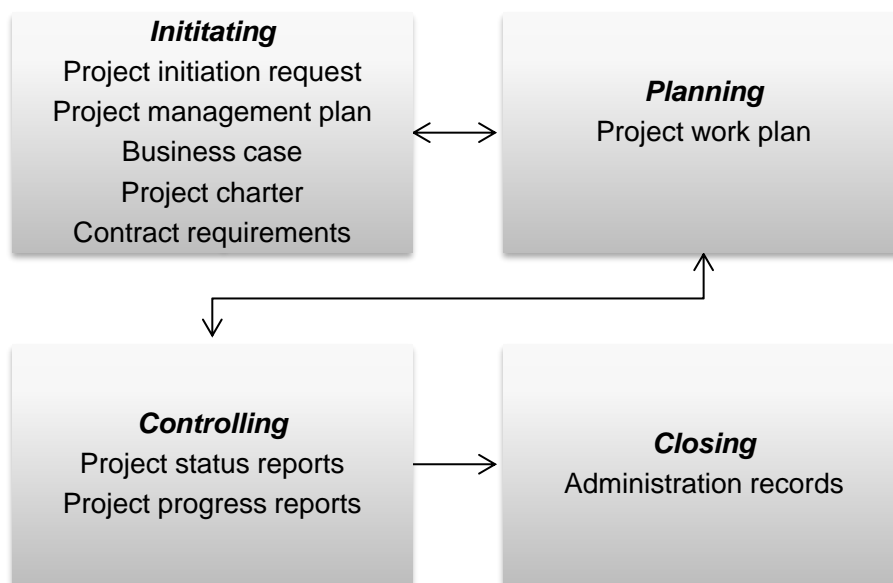


Figure 57 – Financial management throughout the project life cycle

7.1.1 Initiating

The funding availability is a strong variable for choosing a development approach, so it needs to be defined in early project stages. It does not only affect the development approach, but also decisions towards the product and the investment. At the end of the initiation stage, a project charter is obtained. The inputs for obtaining the project plan are the business case, the project mandate, and the statement of work. A project management plan can also be included, Figure 14.

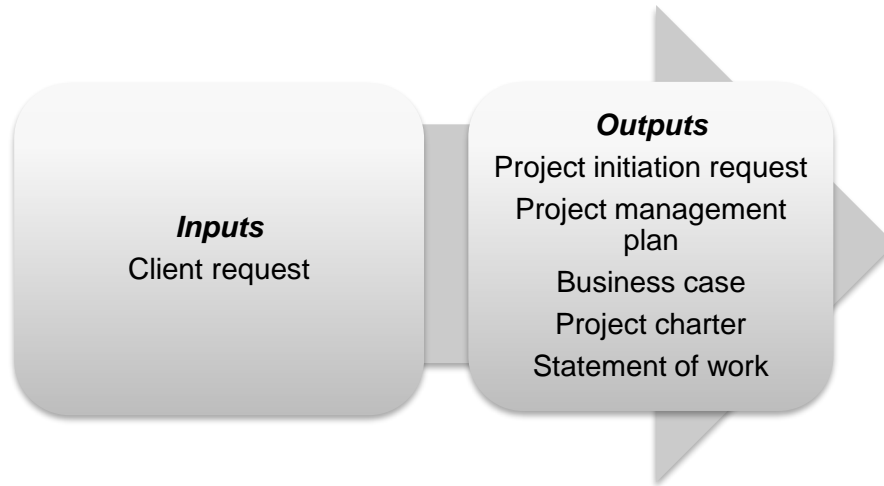


Figure 58 – Initiating stage financial management outputs and inputs

7.1.1.1 Project initiation request

It is a document that formalizes the commitment to explore a problem, need or opportunity further and captures the context. Contains an outline of the business document, even though sometimes it can be referred as a whole process itself that leads to a request form. As stated by (C. Smith, 2005), the purpose of the PIR process is to launch projects with basic information to facilitate and support the PMB’s decision-making process, who also finds out the next main content to be included in a PIR process:

- Why initiate a project?
- Benefits of initiating a project.
- Process overview & flow diagram.
- Online PIR form. (Figure 59 shows an example of a PIR online enquiry)

Figure 59 – PIR form example (Source: (C. Smith, 2005))

Making the project initiating request by a standardized process helps to ensure that all the projects are assessed under the same criteria. 5 are the benefits that (C. Smith, 2005) finds out from applying the PIR process:

- Common agreement between customer, project manager and project stakeholders.
- Opportunity to find and bring to light any serious problems or questions that require immediate attention prior to initiation.
- Prevention of costly mistakes that can accompany the initial excitement of a new project.
- Clearing up any false expectations.
- Confidence that the project manager will be capable of delivering the project.

7.1.1.2 Project management plan

Document or set of documents that defines how the project is undertaken, monitored, and controlled (*PMBOK® Guide Seventh Ed, 2021*). It overviews the project's value proposition, execution steps, resources, communication tools and protocols, risks, stakeholders (and their roles) and the deliverables involved in a project's completion. Its documents include an executive summary, Gantt and team charts, risk assessment and communication- and resource-management subplans. (*What Is A Project Management Plan? – Forbes Advisor, s. f.*)

Among the content, the basic ones defined by (*What Is A Project Management Plan? – Forbes Advisor, s. f.*) can be found:

- Executive summary.
- Timeline or Gantt chart.
- Risk assessment.
- Team chart.
- Communication subplan.
- Resource management subplan.

7.1.1.3 Business case

The business case is the document containing the justification for the investment in the project in time and effort in monetary terms. It shows the transformation of the opportunity into organization benefit by adding information about the needs, objectives, expected results and economic aspects of the project. (*Watt et al., 2014*) includes the next information within the business case:

- A detailed description of the problem or opportunity with headings such as Introduction, Business Objectives, Problem/Opportunity Statement, Assumptions, and Constraints.
- A list of the alternative solutions available.
- An analysis of the business benefits, costs, risks, and issues.
- A description of the preferred solution.
- Main project requirements.
- A summarized plan for implementation that includes a schedule and financial analysis.

But it is not the only content to be included, being the following ones also necessary:

- Strategic alignment (reason and needs for the project and the strategy to achieve the value).
- Contract requirements.
- Economic feasibility study.
- Return on investment.
- Expected key performance indicators measurement.
- Timescale.
- Project brief.
- Intended value.
- Project justification.

7.1.1.4 Project charter

Built on the business case, it is a more project-oriented document defining the project scope, high-level requirements, and deliverables. The objectives by means of scope, time, cost, and quality, as well as the risks, constraints and project milestones and deliverables are reflected. Resources are also within the content along with the preliminary delineation of roles and responsibilities, outlining the project objectives, identifying the main stakeholders, and defining the authority of the project manager. It serves as a reference of authority for the future of the project. The purpose of a project charter as stated by (*Watt et al., 2014*) is to:

- Provide an understanding of the project, the reason it is being conducted, and its justification
- Establish early on in the project the general scope
- Establish the project manager and his or her authority level. A note of who will review and approve the project charter must be included.

A project charter should include as stated by (*Webster, 2021*):

- Purpose and objectives of the project in clear, concise language
- Requirements of the project at a very high level and without much detail
- Project description in a paragraph or two that explains the project
- Known high-level, major categories of risks for the project
- Schedule of events with the start and end dates
- Major events or milestones along the path.
- Budget or summary of how much the project will cost
- Requirements from the organization for approval, including what to approve, who will approve, and how to get the approval
- Key players or stakeholders in charge of which parts of the project and who will approve the plans to go through
- An introduction of the project manager, project sponsor, and their authority level.

7.1.1.5 Statement of work (SOW)

(PMBOK® Guide Seventh Ed, 2021) defines the statement of work as “a narrative description of products, services, or results to be delivered by the project.” It creates the foundation for the delivery of services or products (Singh, 2022) and it’s an extremely detailed work contract that defines the terms and conditions agreed upon between parties and lays de groundwork for the project plan, a binding agreement between client and vendor that describes the terms and conditions for the execution of a project’s scope of work (Landau, 2021).

The next content should be included (Landau, 2021):

- Introduction defining the project and who is involved on it.
- Purpose statement including also deliverables and return on investment.
- Scope of work, process, outcomes, time.
- Workplace (site-specific central facility).
- Work breakdown structure.
- Milestones and detailed schedule (specific counts).
- Deliverables.
- Standards and testing.
- Project success definition.
- Project requirements.
- Payment terms.
- Security issues, restrictions around hardware or software, and others.
- Closure defining deliverables acceptance criteria.

7.1.2 Planning

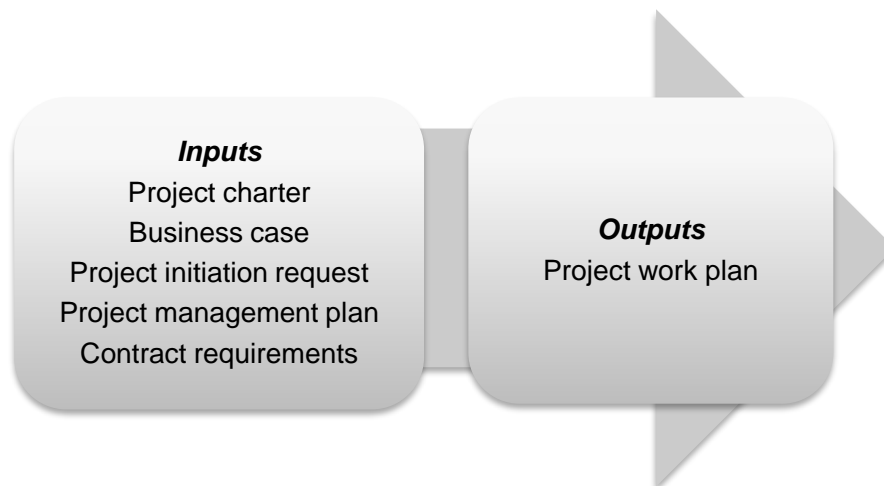


Figure 60 – Implementing and controlling stages inputs and outputs

7.1.2.1 Project work plan

The Project Work Plan documents all project activities needed to achieve the project goals along with their detailed effort/cost estimates, their schedule and resulting project duration and resource requirements. The Project Work Plan will be used as the basis to

monitor the progress and control the project. (*PM2 project management methodology Guide 3.0, 2018*).

The main content to be added into a project work plan defined by (*Landau, 2023*) is:

- Goals and objectives defining one primary and then some smaller.
- Main work plan.
- Work plan objectives.
- Scope of work plan.
- Resources, roles and responsibilities.
- Work plan budget or project financial plan.
- Work plan schedule.
- Risk, assumptions and constraints.

7.1.3 Controlling

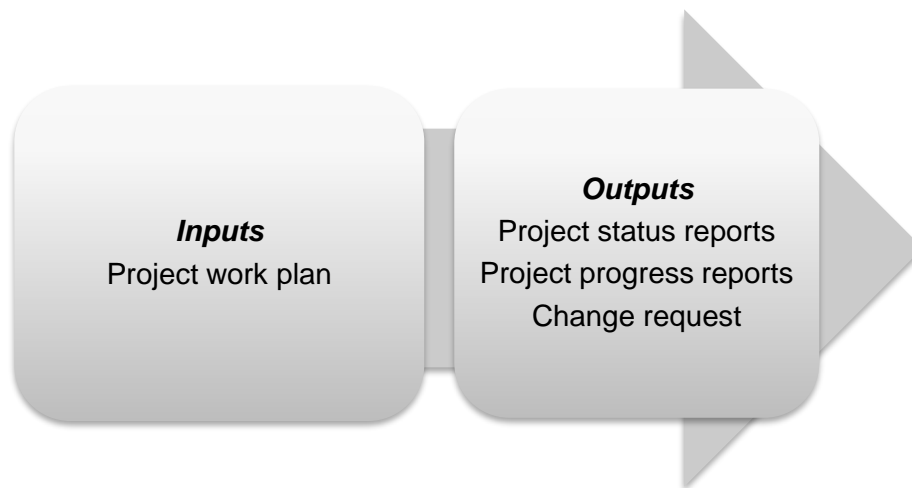


Figure 61 – Implementing and controlling stages inputs and outputs

7.1.3.1 Project status reports

(*PMBOK® Guide Seventh Ed, 2021*) includes this report among the reports chapters and defined it as the document that reports the current status of the project.

It includes tracking information on costs, scheduling, scope/changes, risks and issues, as well as reports on the status of important milestones for the moment in which it was initiated. (*Keup, 2021*) defines that the difference with a project progress report is this detail that the progress report is done for a period of time while the project status report is done in a specific moment of the project. This document is compared against the project work plan. (*Status Report, s. f.*) states that “project managers use status reports to keep stakeholders informed of progress and monitor costs, risks, time and work.”

The content of this document includes the following (*Carroll, 2021*):

- A summary of project details, including program and project name, start and launch dates.
- A list of key team members, stakeholders, and project owners.

- The status date and cadence of the report (daily, weekly, monthly, quarterly).
- A summary of the project scope and budget.
- A timeline of key and cross-project dependencies (if any) to show what must occur before something else can start.
- Call-out of key issues and blockers to address, and what is being done about them.

7.1.3.2 Project progress reports

The project progress report as defined by (Keup, 2021) is a document that communicates what has been happening in the project, over a set period of time, to stakeholders. Therefore, the content found for the project status report should be expanded for a period the chosen period of time. Figure 62 shows an overview of a project progress report.



Progress Report

Project Name:	Reporting Period:
Stakeholder:	Owner:
Project Manager:	Project Due Date:
Compiled By:	Date Submitted:

Summary

Item	Current Status	Prior Status	Summary
Project Status	On Time	Delayed	[Brief synopsis]
Scope	Choose an item.	Choose an item.	
Schedule	Choose an item.	Choose an item.	
Cost	Choose an item.	Choose an item.	
Risk	Choose an item.	Choose an item.	

Tasks

Task	Status	Objective	Planned	Actual	Progress Complete	Deliverable
[Name of activity]	In Progress	[What's the objective]	[When is it planned to be done]	[When was it completed]	25%	In Progress
	Choose an item.				Choose an item.	Choose an item.

Figure 62 – Project progress report (Source: (Keup, 2021))

7.1.3.3 Change request

A change request document outlines modifications to some aspects of the project or organization such as project deliverables or organizational modifications. It is usually at a high level and can come from within or outside the organization (Yarbrough, 2021). Their purpose is to document details about the aspects that need to be altered. The main content found by (Yarbrough, 2021) is the next one:

- Title
- ID Number
- Type of Request
- Source: Internal or External Request
- Short Description

7.1.4 Closing



Figure 63 – Implementing and controlling stages inputs and outputs

7.1.4.1 Lesson learned

Lessons learned is the knowledge gained from the process of conducting a project as defined in (*«How to Do Lessons Learned in Project Management», 2019*). The lessons learned can be seen as a process itself consisting of 5 steps (identify, document, analyze, store and retrieve) as in Figure 64 can be seen (*Lessons Learned, s. f.*).

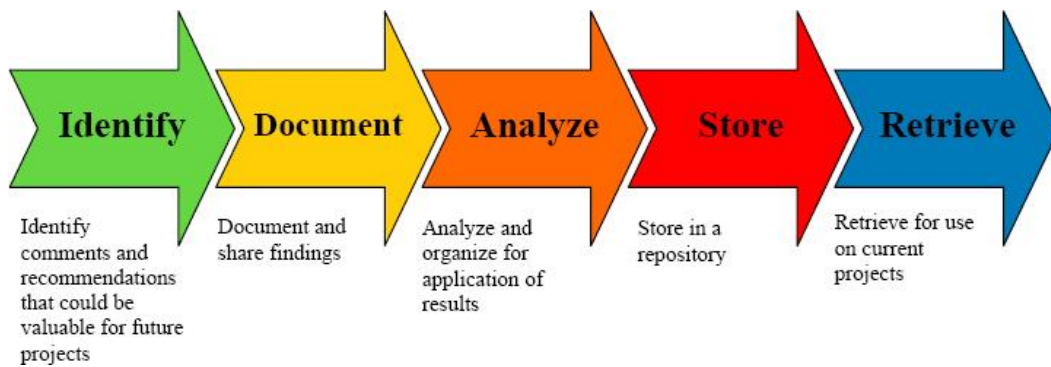


Figure 64 – Lessons learned process (Source: (*Lessons Learned, s. f.*))

Even though they are usually documented at the end of a project, lessons learned occur at any point of the project. Figure 65 shows an example of a lessons learned report. The detailed report should include the information gathered in the lessons learned sessions, and additional input and recommendations from participants (*«How to Do Lessons Learned in Project Management», 2019*).

Lessons Learned Template				
Today's Date: 1/2/2023 Project Name: My Project Project Manager: George Washington Notes: (add any extra info here)				
WIN or ISSUE	Describe What Happened	What Was the Impact?	How Does This Change Future Projects?	Action Items
WIN	time tracking system with the team to test whether or not productivity would improve	We saved 200 hours of time and delivered the work 2 weeks early	We will roll out time tracking to all teams in the company	1. Purchase software licenses for all employees 2. Send email explaining why time tracking is necessary
ISSUE	project was out sick for 2 weeks and there was no available replacement, so we had to wait for her	The project was delayed 4 weeks and the client was upset. A \$25,000 credit was issued to the client	We need to have redundancy in the IT department to ensure there is always someone available	Chat with CEO and HR about hiring additional IT help
WIN	The client was so happy with the final presentation that she offered us a 2 year exclusive contract!	This contract is going to double our revenue growth over the next 2 years	The new style of in-person client presentation should be used on more projects, when possible.	Share the new client presentation format with other teams

Figure 65 – Lessons learned template (Source: (*Lessons Learned Template, s. f.*))

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9 ANEXO 1 – Scientific paper

Abstract

A study about the finance of projects for the project manager role is done in this work. It is a very general topic which has a high influence on every aspect of businesses. Financial management is not always carried out by the project manager, though role-related tools and techniques are necessary. A review of the principal five project management standards is first conducted, after a comparison is made between them, and additionally the standard for construction is added. A bibliometric review is also done comprising journal articles and reviews from the Scopus database for the last decade. The current state of research by analyzing the standards and the available bibliometric data as well as the most active research areas are identified and discussed. Finally, a new methodology is proposed based. To finish further research is recommended based on the gaps found.

Keywords: Finance of projects; Financial risk assessment; Project benefit management; Project cost estimation; Project investment appraisal

1. Introduction

The finance of projects is one of the most influencing aspects in the success of a project. It is present through all the life cycle of it. Much information has been published and investigated for the project finance model. This model is different from the global model of finance of projects, involving the latter all the types of financing while the former focuses on itself. Financial Management means planning, organizing, directing, and controlling the financial activities such as procurement and utilization of funds of the enterprise. Good financial management of the economic resources of a company is of prominent importance. In fact, finance is so indispensable today that it is rightly said to be the blood of an enterprise. Without adequate finance, no enterprise can possibly accomplish its objectives (Pandey, s. f.). It can also be said that there are some factors affecting the choice of the source which are cost, financial strength and stability of operations, risk profile, effect of creditworthiness, tax benefits, control, flexibility and ease, purpose and period,

form of organization and legal status (*Factors Affecting the Choice of the Source of Funds - GeeksforGeeks, s. f.*).

The role of a project manager in the field of financial management within a project is not always treated in the same way. As stated by (Pinto, 2009), the financing area of the project is, in the case of many projects, considered to be within the stakeholder area of influence and, because of that, it is not directly addressed by the project manager. But without project management tools and techniques and without correctly studying the cost of the project, it's impossible to know exactly the amount of money that the project needs and the cost baseline that influences the finance need of the project. Many statements of what a project manager is responsible for can be found in many different sources, but for example, in the definition found in the APMA, it says that "the project manager is the responsible for day-to-day management of the project and must be competent in managing the six aspects of a project, which are scope, schedule, finance, risk, quality and resources.

This means that the approach done in many projects with the project manager not directly addressing the financial management is not the most correct one since one of the responsibilities of a project manager is supposed to be the finance. (Turner, 2006) identifies through several project management standards 17 inherit components of project managements, being the component 3 the financial management. This leads to the fact that the standards for project management should be gathering the needed information for that area. As a result, financing through the main project management standards and within the scientific bibliography must be thoroughly investigated.

A high number of documents and every type of book or standard can be found for the topic of financing. Until now, most of the reviews have been focused individually on the factors that involve the financing activity. This study checks 5 project management standards and bibliometric data using scientometric analysis for the existence of a guided process for the finance of projects for project managers along with tools and techniques.

The structure of the paper is as follows. Section 2 provides the methodology followed. Section 3 explains the context, while Section 4 states the scope. Section 5 includes the state of the art. Section 6 gathers the obtained results for the analysis and Section 7 includes the new methodology proposal and delivers conclusion remarks and recommendations.

2. Methodology

For the study of the standards the methodology focuses on the most representative standards for project management. In this way, PMBOK

Guide Seventh Edition, IPMA ICB 4.0, PM2 guide, ISO 21500:2012 y PRINCE 2 training manuals are found to be the biggest associations within the area, and afterwards, a comparison between standards is conducted. Finally, the standard for construction Construction Extension to the PMBOK Guide is added into the study comparing it to the formers within the results.

To complement the standards, it is decided to conduct for the topic a scientometric analysis of the scientific data in the area. The main reason for choosing this analysis is that, as (Oliveira et al., 2019) wrote, "It is an essential element that provides researcher means to identify and support paths towards the development of scientific projects." Nowadays, huge amounts of articles can be found through different scientific database platforms, and to identify and analyze the scientific performance of articles, authors, etc., scientometric provides research with instruments. As a summary, after the field of study was chosen based on the interest of the author for the topic, the steps followed are described in Fig. 1.

3. Context

Financial management knowledge is not an area treated just within some industries but affects all types of projects. In this way, the standards for the project management should cover the financial management area of knowledge, or at list, provide project managers with the tools, techniques, or best practices. (Martins, 2017) pointed out that despite the large amount of work relating project scheduling and cash-flows, less attention has been given to borrowing strategies for supporting projects' costs. In many practical problems, loaning is not a choice but the unique option for initiating the process.

In fact, an adequate loaning strategy is crucial, not just for launching the project but also for guaranteeing its financial success. In this sense, the current research aims to study how the mentioned most relevant standards do that covering and if the project managers are properly guided not only through the cost management or budget definition for example, well known covered within the standards, but also through the whole financing area.

In the field many studies have been carried out and much information about the different available sources referring to its managing through the time has

been written. This information can be found within many articles, books, journals, magazines, etc., but clear steps to be followed should be given to the project managers. Many authors have provided knowledge to the field of financial management, which (Pandey, s. f.) defines as that part of the management activity which is concerned with the planning and controlling of firm's financial resources. It deals with finding out various sources for raising funds for the firm. (Pandey, s. f.) also gives the functions for the financial manager, which can also be understood as the steps to be followed

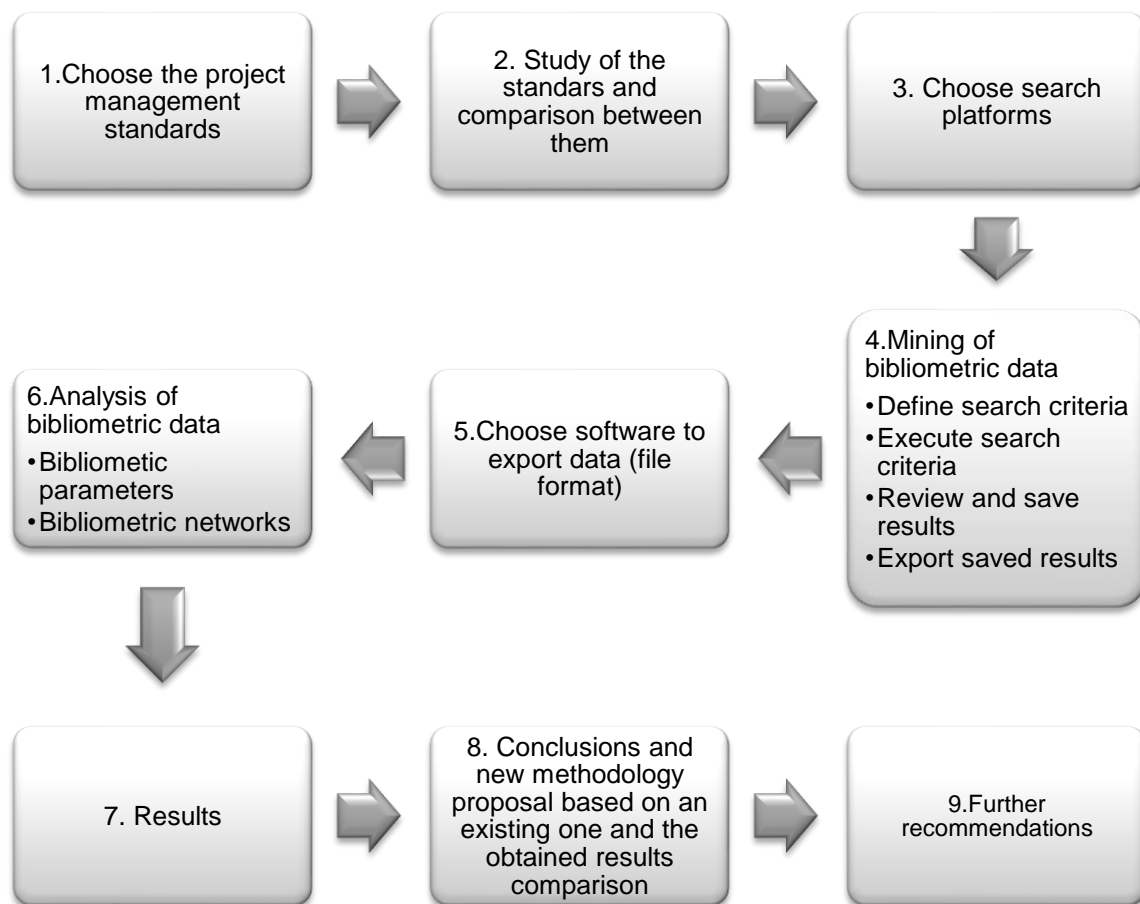


Fig. 1 – Steps for carrying the analysis.

4. Scope of the research

The scope of this work is described through five main objectives or purposes in terms of financing for projects to what it is expected from a project manager role:

1. Study the state of the art of financing within the most relevant standards for project management and make a comparison between them. Study the financial management area of the PMBOK adaptation to the construction sector.
2. Review the bibliometric data related to the finance of projects that researchers provided through the last decade (2012-2022).
3. Identify the trends within the scientific data.
4. Propose a new methodology for project managers for financial management.

5. Propose new lines of research for future investigations identified through the gaps.

5. Analysis of the state of the art

Finance of projects within project management standards. A comparison between them.

To develop a framework for the study of the funding of projects, it is helpful to begin by considering the reference standards within the Project Management discipline. The Construction extension to the PMBOK Guide Edition is also included studying the financial management area following the stated by (Pinto, 2009).

After studying each standard, a comparison between them is given from Tab. 1 to Tab. 4 with regards to the most relevant aspects related to the treatment of the finance of projects representing the current state of the art.

Tab. 1
 Standard bases comparison (Source: Prepared by the author)

Standard bases	
PMBOK Guide Seventh Edition	Principles and performance domains. Method, models, and techniques are provided and linked to each performance domain. Project managers are the focus, defining their responsibilities.
IPMA ICB 4.0	Domains and individual competences. Method, models, and techniques are provided but not linked to the competences. No specific role definition is given.
ISO21500:2012	Concepts and processes include primary inputs and outputs for each of them. Project managers are the focus, defining their responsibilities.
PM2 guide	Elements that are recognized best practices that included in other standards and methodologies. Specific roles are given including their expected responsibility for each phase activity and output. Tools and techniques are included.
PRINCE2 training manual	Principle-based methodology containing 7 principles and 6 variables or performance targets. 4 main parts. Project managers are not the focus, the project is seen for which all the roles are mentioned. The project manager roles are further extended.

Tab. 2

Standard defined guidelines for financing comparison (Source: Prepared by the author)

Guidelines for financing or related factors	
PMBOK Guide Seventh Edition	<p>No clear guidelines are given. There is a lack of clear financial management methodology affecting the finance of the projects provided.</p> <p>References to the factors cost, risk, taxes or control can be found through the text for the functions of the PM, as well as included within the domains and principles.</p>
IPMA ICB 4.0	<p>Financing methodology is provided with clear guidelines.</p>
ISO21500:2012	<p>Subject groups with processes related to the costs and risks management are included clearly within the planning, implementing, and controlling process groups.</p>
PM2 guide	<p>No clear guidelines are given. There is a lack of clear financial management methodology affecting the finance of the projects provided.</p> <p>References to the factors cost, risk and issues can be found through the text for each activity.</p>
PRINCE2 training manual	<p>No clear guidelines are given. There is a lack of clear financial management methodology affecting the finance of the projects provided.</p> <p>References to the factors cost, risk and or a extended business case development is included.</p>

Tab. 3

Standard defined guidelines for financing (Source: Prepared by the author)

Relations between other tasks and responsibilities	
PMBOK Guide Seventh Edition	<p>Relations between performance domains and at the same these to the principles are provided.</p>
IPMA ICB 4.0	<p>The relations between competence domains and for different areas are given.</p>
ISO21500:2012	<p>Process relations between them are provided.</p>
PM2 guide	<p>Relations between activities are given as inputs and outputs of one and another.</p>
PRINCE2 training manual	<p>The principles and the variables are included on each step of the project phase where necessary.</p>

Tab. 4

How to provide for the activity on each standard (Source: Prepared by the author)

How to provide for the activity	
PMBOK Guide Seventh Edition	Methods and artifacts for the developing of the activities related to some factors that are intrinsic to the financing are provided, even though they are not directly related to each in the text.
IPMA ICB 4.0	Knowledge, skills and abilities, key competence indicators and measures are provided. Tools or techniques to develop them are not included. It is a what but not how to guide.
ISO21500:2012	Primary inputs and outputs are included for each process. Tools or techniques to develop the inputs or outputs are not included in the standard. It is a what but not how to guide.
PM2 guide	Tools and techniques as well as templates are included to develop the defined activities within the standard. It is a what and how to guide.
PRINCE2 training manual	Detailed techniques are not covered, activities for each stage are given. It is a what to but not how to guide.

Construction Extension to the PMBOK® Guide

Through the life cycle of construction projects, four are the project manager financial management responsibilities areas:

1. Accounting for financial resources of the project.
2. Managing costs and profits.
3. Managing cash flows.
4. Making financial decisions or providing the necessary verified information to the project sponsor for making such decisions.

The Construction Extension to the PMBOK® Guide indicates that the financial management area determines how the project will be financed, including the processes to acquire and manage the financial resources for the project. It also states that “It is more

concerned with revenue sources and monitoring net cash flows (financial management) for the construction project than with managing day-to-day costs (cost management).” the (*Construction extension to the PMBOK guide, 2016*), although long-term financing may include both managements. The type of finance is focused on privately funded construction projects.

The financing needs to be effective and efficient to achieve objectives and the details of the ongoing of the finance of the project and the requirements are included in the contract between the owner of the project and the contractor. Three are the major processes for the finance of construction projects:

- Financial Planning.
- Financial Control.
- Administration and Records.

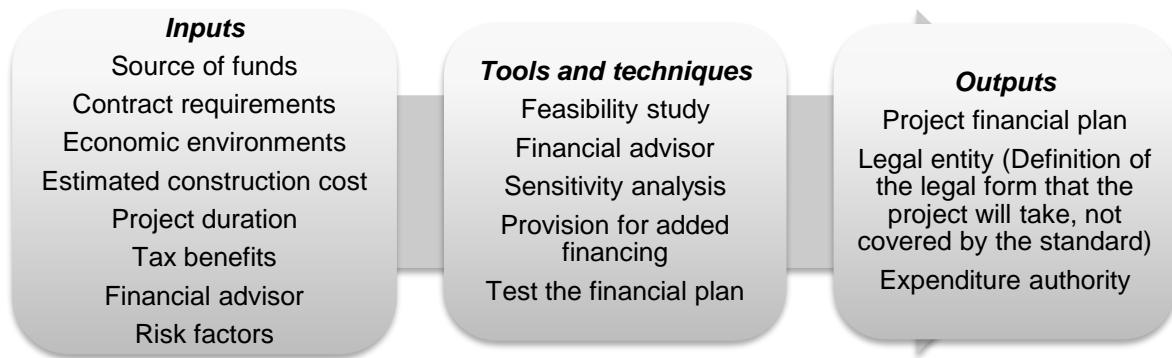


Fig. 2 – Financial planning

Financial planning

In this phase the financial requirements are set, along with assigning the project roles and responsibilities, tasks, resources, etc. In Fig. 2 the inputs, tools and techniques, and outputs for the financial planning stage are provided:

The source of funds usually comes from the central financing system of the company, which may be a mix of borrowing from financial institutions, retained profits, and financial reserves.

The project financing may occur incrementally in different phases of the project. So that the proper ongoing of the project is ensured, the financial and project plans should consider the funding milestones. The funding sources selection depend mainly on the project's creditworthiness and project sensitivity to changes in interest rates.

The economic environment, as mentioned in the Construction Extension to the PMBOK Guide, is an external factor that is outside the project manager's control. Anyway, aspects like economic issues such as country risk or currency fluctuations need to be taken into account because they can either increase or decrease the project cost (*Construction extension to the PMBOK guide, 2016*). The analytical techniques, feasibility studies and sensitivity

analysis will provide for long term projects the profitability of them within the given parameters as well as the viability with the cash.

A proper financial plan allocates risks among participants, investors, customers, and interested third parties. Some risks could be favorable for financing, and a risk analysis is usually asked by those institutions providing the fundings. But this is not the last aspect to consider when planning financing, as another important factor to consider in the financial planning of the project is that in many countries interest is tax deductible while dividends to shareholders are not. A taxation structure should be created for the project studying the advantages of tax depreciation and other taxable revenues.

The project financial plan consists of a clear identification of the financial requirements and of the means to finance them. With this comprehensive document, all parties must understand by whom and when all the necessary equity, debt, and insurance are to be supplied. The expenditure authority is usually determined by organizational policies. that must also consider the fact that dual signatories and levels of spending and approval should be considered (*Pinto, 2009*).



Fig. 3 – Financial control

Financial monitoring and controlling

This process ensures that financial control and cost control are executed in the most effective way so that all items are within budget as well as the financial cash forecast. In Fig. 3 the inputs, tools and techniques and outputs for the controlling and monitoring can be seen.

“The project accounting system should be similar in structure to the WBS, showing the breakdown of the total project in more controllable modules” (*Construction extension to the PMBOK guide, 2016*). The controlling is done by comparing the actual spending and revenue against budget and cash flow forecasts so that deviations are found. Financial records need to be kept for proper controlling.

As quoted in the Construction Extension to the PMBOK Guide, either external or internal financial audits ensure correct accounting methods and financial practices are being maintained (*Construction extension to the PMBOK guide, 2016*). Unseen problems could arise from these audits. The basic financial statements are the prime focus, and the reports could contain warnings of overinvestment in fixed assets, poor credit arrangements, and improper use of project funds.

Regularly analyzing the cash flow data trends based on unique characteristics of the project could be obtained revising like that the forecasts for the remaining

duration. Financial reports are also another monitoring and controlling tool, as “for projects that need full financing, management and any lenders involved require periodic financial reports.” (*Construction extension to the PMBOK guide, 2016*)

Experts could be added to the project so that advice is given. The Construction Extension to the PMBOK Guide states that “the use of professional expertise such as accountants, legal advisors, insurance and investment brokers, or others who will advise on issues related to monetary policies, investor relations, the stock market, wills, trusts, funds, etc., may add considerable value towards avoiding financial pains.” (*Construction extension to the PMBOK guide, 2016*).

Finally, evaluations such as Ex-Post evaluations could be done to measure the effectiveness and the aims fulfilment as it is said in the Construction Extension to the PMBOK Guide standard (*Construction extension to the PMBOK guide, 2016*). By analyzing different financial parameters, the proposed versus the achieved benefit is compared.

Administration and records

This process ensures that financial information is administrated and that records are well made. Fig. 4 shows the inputs, tools and techniques and outputs.



Fig. 4 – Administration and records

A scientometric based analysis of the finance of projects for project management within the scientific bibliography

In addition to reviewing the available data within the most representative standards for project management, a scientometric analysis for the available bibliometric data for the topic is conducted. As mentioned by (Oliveira et al., 2019), "Bibliometric analysis is an indispensable statistic tool to map the state of the art in a given area of scientific knowledge and identify essential information for various

purposes, such as prospecting research opportunities and substantiating scientific researches." This study discusses the most active research areas for the field, and based on the assessment of the literature, future research is recommended. In Tab. 5, a summary of the documents found for each keyword with and without the chosen filters applied is shown. The searched keyword "financial risk assessment" resulted in most documents (1506), while "project investment appraisal" resulted in the least documents (35).

Tab. 5 Documents searched in Scopus database

Keyword	Document	Documents results after filters
Finance of projects	3528	436
Project cost estimation	1834	229
Financial risk assessment	9931	1506
Project benefit management	4149	542
Project investment appraisal	176	35
Total (summary of each)	19618	2748

• **Annual publication trend**

The annual publication trend for each searched keyword for the last decade has been represented in Fig. 5. In the diagram the total number of publications for each year is represented in a bar chart, to which the number of documents published for each keyword has been transposed with a line chart.

For the last decade an increasing publishing trend can be observed for the total amount of documents every year,

increasing the number of documents published from 2012 to 2022 in approximately the double. In 2012 and 2017 a peak between can be observed anyway with regards to the next year. The period from 2018 to 2022, the last 5 years, could be used for the analysis since it seems to be a confirmed trend.

It is important to mention here that there are possibilities of duplicate publications.

while searching different keywords that are also added in the sum of

publications. This is a limitation in the study.

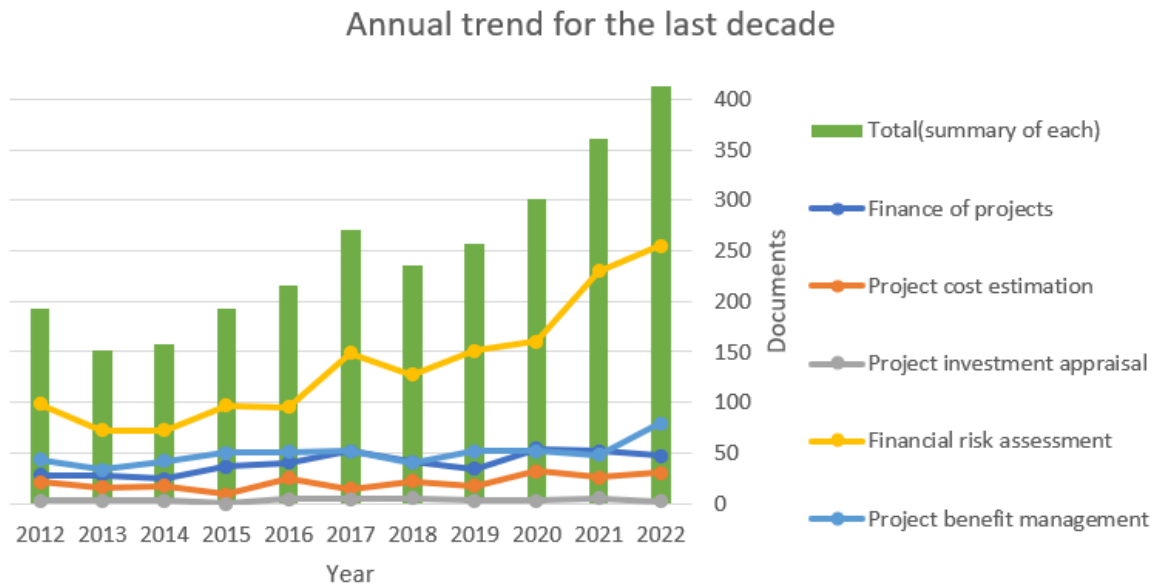


Fig. 5– Annual publication trend for individual search

• **Top publication sources**

Tab. 6
Top publication sources

N/A	Source document	Documents	Citations	Total link strength
1	Energy economics	106	3208	733
2	Journal of construction engineering and management	79	1926	786
3	International journal of project	74	4585	586
4	Expert systems with applications	68	1959	165
5	Resources policy	57	824	618
6	Mathematical problems in engineering	53	165	303
7	Applied economics	46	369	333
8	Engineering, construction, and architectural management	42	484	61
9	Energies	41	463	70
10	Journal of cleaner production	40	1258	84
11	Energy	40	981	59

The depiction of development and innovation analysis is made possible by source mapping (Ahmad et al., 2021). The analysis is done by using VOSviewer with Scopus data file. "Bibliographic coupling" was chosen as the "analysis type," and "sources" was

chosen as the "analysis unit". A source's minimum number of documents was set at 40, and from the 624 sources just 11 met the set parameters.

Tab. 6 lists the top sources/journals that published at least 40 publications providing data with the any of the

keywords defined for the study, as well as their citation counts and total link strength. The top three journals in terms of published documents are energy economics, journal of construction engineering and management and international journal of project management with respective documents of 106, 79, and 74. However, the top three journals with respect to citation count were energy economics with 4585, expert systems with applications with 3208, and international journal of project management research with 1959 citations.

The network visualization of sources with at least 40 articles published is shown in Fig. 6. The node size corresponds to the contribution of the journal's article count; a bigger node size suggests a greater contribution (Ahmad et al., 2021). Furthermore, nodes (sources/journals) of the same color show clusters of connected journals detected using VOSviewer analysis. Three clusters have been observed shown by red, green, and blue. Cluster 1 (red) comprised 4 items, cluster 2 (green) contained 4 items and cluster 3 (blue) with 3 items.

The connecting links between the research sources reflect the number of publications that contain co-citations. In addition, the number of times two journals have been cited in the same article is shown by the connection strength (Ahmad et al., 2021).

- **Most cited keywords**

Keywords are important research materials because they identify and represent the research domain's fundamental field (Ahmad et al., 2021; H.-N. Su & Lee, 2010) and they distinguish and emphasize the basic subject of the study domain (Khan et al.,

2022). For this analysis, "co-occurrence" was chosen as the "kind of analysis," and "all keywords" was chosen as the "unit of analysis", in VOSviewer.

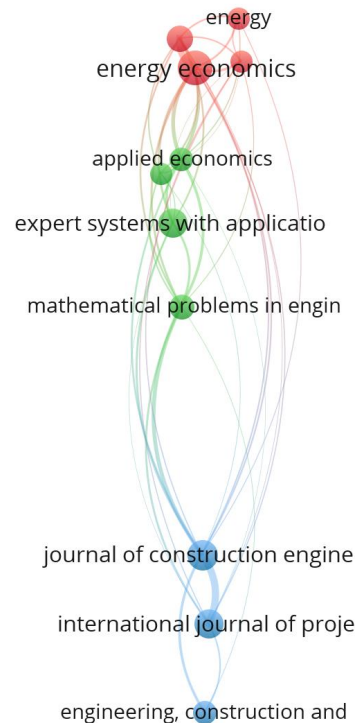


Fig. 6– Source mapping with a minimum of 40 publications in the research of finance of projects (Source: VOSviewer)

The minimum number of repetitions for a keyword was set to 15, and 44 of the 7548 keywords met the requirements with the set criteria. From these 44, Tab. 7 records the keywords with a minimum occurrence of 50.

The five most often occurring terms in the topic study field are risk management, project management, risk assessment, financial risk and risk. Fig. 7 shows the co-occurrence visualization of keyword mapping, as well as their connections and the density associated with their correlation frequency. The size of a keyword node in Fig. 7 denotes its frequency, whereas its location denotes its co-occurrence in publications (Ahmad et al., 2021). In addition, the

graph expresses that the top keywords have larger frames than the rest, signifying that these are essential keywords for a real investigation in the research of finance of projects.

Clusters of keywords have been colored differently in the network to highlight their co-occurrence (Ahmad et al., 2021). The colors red, green, dark blue, light blue, purple and yellow were used to identify six clusters. Cluster 1 (light blue) contained 10 items, cluster 2 (green) 10 items, cluster 3 (dark blue) 7 items, cluster 4 (yellow) 7 items, cluster

5 (purple) 6 items and cluster 6 (red) 5 items. Risk management, project management, risk assessment, and other prominent keywords display yellow signals indicating a greater density of occurrences. This finding will help ambitious researchers select keywords that ease the discovery of published papers on a specific topic. (Khan et al., 2022) with finance and risk management. This link also indicates that these keywords have been frequently used conjointly in the published articles.

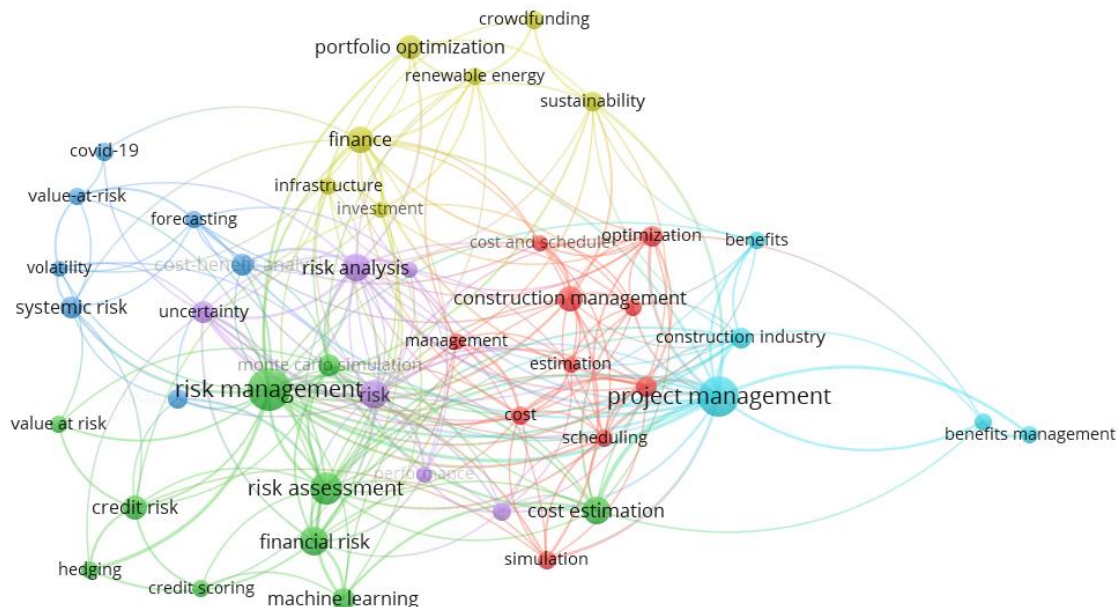


Fig. 7– Keywords co-occurrence network visualization (Source: VOSviewer)

Tab. 7
List of keywords with a minimum occurrence of 50 in the research of finance of projects

N/A	Keyword	Occurrence	Total link strength
1	Risk management	131	79
2	Project management	120	87
3	Risk assessment	71	38
4	Financial risk	55	29
5	Risk	55	30
6	Cost estimation	53	28
7	Risk analysis	51	44

- **Most cited authors**

Citations show a scientist's impact in a particular field of research (*Khan et al., 2022; F. Yu & Hayes, 2018*). The "type of analysis" in the VOSviewer was set to "co-authorship," and the "unit of analysis" was set to "authors." The minimum number of documents for an author was kept at the maximum that VOSviewer found was 3, and 6 out of 2502 researchers satisfied this requirement. The authors with the most articles and citations in the field of geopolymers, as assessed from the bibliographic data using VOSviewer, are included in Tab. 8. according to data extracted from the Scopus database. The total number of citations was divided by each author's total number of publications to get the average citation

count, and, additionally, the h-index for each author is calculated in Scopus. The h-index is used for displaying and comparing the productivity and impact of published work of scholars. (*Ahmad et al., 2021; Khan et al., 2022*). It is complicated to assess the effectiveness of a scientist when all parameters, such as the quantity of documents, overall citations, and average citations, are taken into account (*Khan et al., 2022*). Alternatively, the researcher's ranking will be evaluated separately for each component. Lefley F. has the most documents published, while Sousa V., Almeida N.M., and Dias L.A. have the most citations. When looking at the average citations, the highest average is given by Sousa V., Almeida N.M., and Dias L.A.

Tab. 8

List of authors having a least 3 publications in the research of finance of projects

N/A	Keyword	Documents	Citations	Average citations	Scopus h-index	Total link strength
1	Lefley F.	4	20	5	10	0
2	Cheng M.-Y.	3	79	26	37	0
3	Tran D.-H.	3	79	26	33	0
4	Sousa V.	3	209	70	43	0
5	Almeida N.M	3	209	70	11	0
6	Dias L.A.	3	209	70	5	0

- **Most cited articles**

The number of citations a publication receives signifies its impact in a certain research domain (*Khan et al., 2022*). Articles with a high number of citations are regarded as landmarks in the field of research (*Ahmad et al., 2021*). To analyze documents based on citations, the "type of analysis" was set to "bibliographic coupling" and the "unit of analysis" to "document" in VOSviewer.

A document's minimum citation count was set at 80, and 90 of the 2539 documents (excluding duplicates) met

this requirement. Tab. 9 lists the top 9 most cited research articles, as well as their authors, publication year, and total link strength. Netemeyer R.G (*Fernandes et al., 2014*) obtained 757 citations for their publication "Financial literacy, financial education, and downstream financial behaviors". Volm J.M (*Bryde et al., 2013*) and Wang G. (*Kou et al., 2014*) received 728 and 588 citations for their respective papers and were listed in the top three. Only 3 articles in this field received more than 500 citations in the last decade. It was also found that there are many more

articles published on the risk management area than in the others, showing these results that the area is of high interest for the research.

Tab. 9
Top 10 articles by VOSviewer with highest citations in the research of finance of projects
(Source: Prepared by the author)

N/A	Document	Title	Year	Citations	Total link strength
1	Fernandes D.(Fernandes et al., 2014)	Financial literacy, financial education, and downstream financial behaviors	2014	757	0
2	Bryde, D.(Bryde et al., 2013)	The project benefits of building information modelling (BIM)	2013	728	1
3	Kou, G.(Kou et al., 2014)	Evaluation of clustering algorithms for financial risk analysis using MCDM methods	2014	588	0
4	Mangla, S.K.(Mangla et al., 2015)	Risk analysis in green supply chain using fuzzy AHP approach: A case study	2015	316	0
5	Basher S.A. (Basher & Sadorsky, 2016)	Hedging emerging market stock prices with oil, gold, VIX, and bonds: A comparison between DCC, ADCC and GO-GARCH	2016	285	5
6	Meng X.(Meng, 2012)	The effect of relationship management on project performance in construction	2012	280	0
7	Škare M.(Škare et al., 2021)	Impact of COVID-19 on the travel and tourism industry	2021	265	0
8	Mazzucato M.(Mazzucato & Semieniuk, 2018)	Financing renewable energy: Who is financing what and why it matters	2018	257	10
9	Cui C.(Cui et al., 2018)	Review of studies on the public–private partnerships (PPP) for infrastructure projects	2018	248	2

- **Top contributing countries**

Certain countries have made and continue to make bigger contributions to the current research domain than others (Ahmad *et al.*, 2021). "Bibliographic coupling" was chosen as the "kind of analysis", and "countries" as the "unit of analysis". A country's minimum quantity of papers was set at 20, and 35 of the 112 countries met this condition. Tab. 10 shows which 20 countries are the most active in terms of the number of publications and citations connected to the present research topic. United States, China and the United Kingdoms provided the most documents, with 527, 498 and 286 documents, respectively. These countries also received the most citations for their publications, with the United States at the top with 9623, then China with 7097, and after that United Kingdom with 6835 citations. The total

number of documents, citations, and connections demonstrates the impact of a country on the present research field (Ahmad *et al.*, 2021). The total link strength indicates how much a country's papers influenced the other countries. Once again, United States has the strongest total link strength of 22595, followed by the China with 18708, and United Kingdom with 17999 total link strength. As a result, the mentioned countries were shown to have the largest influence on the finance of projects. The links of countries based on citations are depicted in Fig. 8 The graphical representation and quantitative record of the participating nations will assist future researchers in the field in making scientific alliances, launching collaborative ventures, and exchanging creative methods and concepts (Khan *et al.*, 2022).

Tab. 10

Top 20 most contributing countries in the research of finance of projects

N/A	Country	Documents	Citations	Total link strength
1	United States	527	9623	22595
2	China	498	7097	18708
3	United Kingdom	286	6835	17999
4	Australia	159	3069	11567
5	Canada	125	2387	6956
6	Italy	110	2066	4971
7	Germany	109	2759	4950
8	France	102	2023	7840
9	Iran	96	1322	4537
10	South korea	89	1423	5764
11	India	87	1535	5815
12	Spain	82	3144	4441
13	Taiwan	66	1313	2554
14	Hong Kong	64	1321	5256
15	Poland	59	845	2413
16	Brazil	59	1029	2017
17	Netherlands	59	2069	5393
18	Turkey	54	1336	2674
19	Malaysia	46	858	3541
20	Japan	45	631	1593

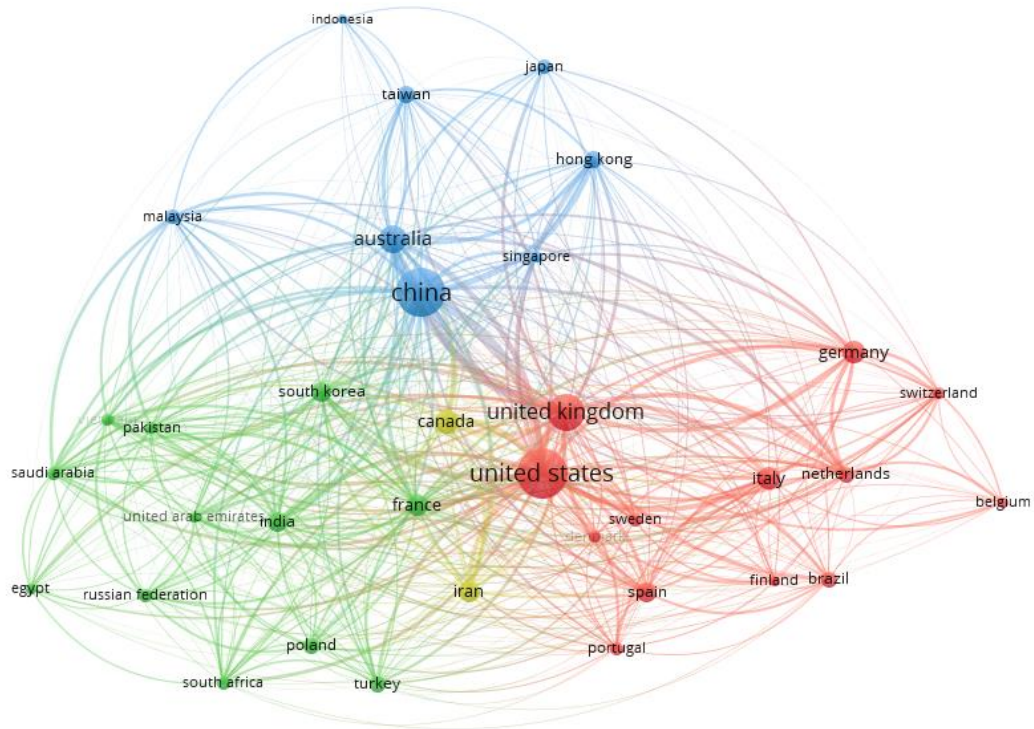


Fig. 8 - Top contributing countries mapping: Network visualization (Source: VOSviewer)

- **Financing within the scientific bibliography**

Financing is a very general term which covers so many different areas not only within projects, but within all the different types of sectors for the professional world, for the familiar areas, etc. After performing a scientometric analysis over scientific bibliography retrieved from the Scopus database on finance of projects, the clearest active research sectors were found to be the renewable energy and construction sectors. The other research areas are not clearly defined areas. This study performed a review of the data founded with the scientometric analysis, so that the trends were mapped, focusing in the documents that cover the field of projects from a project manager point of view.

- **Renewable energy**

Due to the climatic emergency current situation that the world is facing, changes like the European Green Deal

(Un Pacto Verde Europeo, s. f.) that transform the countries all over the world into climatically neutral countries are needed. Sustainable Development Goals (SDGs) and the Paris Agreement for climate change (Taghizadeh-Hesary & Yoshino, 2020) are other goals established by the governments regarding climate change. One of the measures to be implemented is cleaner energy and forefront clean technological innovation. Within this measure is where renewable energy is categorized. One of the key points in the transition into this low emission energies is the ability to obtain enough finance to steer investment in renewable energy (RE) (Mazzucato & Semieniuk, 2018). (Taghizadeh-Hesary & Yoshino, 2020) quoted that “the future of clean energy no longer concerns science and technology; it is all about access to finance” (Donovan, 2015; Taghizadeh-Hesary & Yoshino, 2020).

Green energy projects are large and long-term projects which need of high investments because they are considered infrastructural projects (Taghizadeh-Hesary & Yoshino, 2020). Two are the main characteristics of these types of projects, which are also barriers at the same time, a lower rate of return and a higher risk of investment compared to fossil fuel projects. The fact that the renewable energy projects have a higher risk than the fossil fuel projects make it difficult for banks to invest in this type of project. But this is not the only reason, the risks are spread among consumers and the uncertainty of the prices for the high speed of the technology evolving makes it difficult to access finance (Taghizadeh-Hesary & Yoshino, 2020).

The large upfront investment required in the RE needs to be made efficiently from a cost point of view. For this purpose, the cost of capital (calculated as discount rate) is an important part of the lifecycle costs of RE projects, which is a mixed of the social and private cost of capital (Steffen, 2020). For the appraisal of this type of projects anyway, the private cost of capital, more known as just cost of capital is the one that matters the most (Steffen, 2020). A methodology for this calculation was developed by (Steffen, 2020) in his paper, even though it was based on assumptions and therefore, with limitations due to the confidential nature of the renewable energy sector.

Trying to access to other types of non-banking finance could be a solution, financial institutions for example. (Taghizadeh-Hesary & Yoshino, 2020) anyway, developed a method for the financial institutions of reducing risks in green financing called green credit guarantee schemes (GCGSs) along with the measures adopted by the banks of

having specific programs for a precautionary approach to green lending, as well as compliance and risk management. GCGS would reduce the asymmetry of information and decrease the expected default losses. Furthermore, a way of increasing the rate of return could be the usage of spill overs effects of the projects (Taghizadeh-Hesary & Yoshino, 2020).

On the other hand, financial actors investing portfolios influence in the direction that the technology follows. The risk direction is also another factor, where different trends between the public and private finances can be found, the former tending to higher risks than the latter. Mazzucato and Semieniuk (Mazzucato & Semieniuk, 2018) found through the research conducted within BNEF data from 2004 to 2014, that emphasis should move from the total amount of finance to its composition, what lead to implications for the policies to be established from a financing point of view.

The results obtained by (Mazzucato & Semieniuk, 2018) reported that each type of finance determines the direction of the technology. In this way, the policies adopted need to take care of favoring financial actors, since they will have their priorities. When developing a policy for a determined technology, the knowledge about the heterogeneity in financial actors benefits the policy. Historical trends about the financing adopted previously are also helpful. Attention not only to the upstream phase of the project or technology should be paid, but also to the downstream phase. The coordination of different types of financing within the deployment phase needs to be attended. Finally, to just consider the types of finance from a private or public view is not deepen

enough. It is important to consider the characteristics of the financial actors. Taking care of the development of the policies will be useful to avoid later problems, preventing surprises and lock-ins.

- **Construction**

Construction projects have largely turned out to be much more difficult to manage due to the high number of parameters that the project managers need to take into account. In the last years, the researchers have been focused on the investigation of the available tools for the managing of aspects like risk or the whole project management.

With the introduction of Building Information Models (BIM) project managers were not only provided a way of managing the building in 3D as well as the input of information, but they were also provided with project management tools and processes through the entire life cycle of the project (Bryde et al., 2013). Moreover, the 5D BIM is known as a traditional 3D BIM with scheduling information (the 4th D) and information for estimating the project from the model (the 5th D) (Bryde et al., 2013). Cost reduction is likely to be one of the positive effects arising from the use of BIM, either focused on a phase or in the whole construction cost. The risk management is also improved, even though a negative effect could appear due to the upfront investment for the modelling of the project to win the bid (Bryde et al., 2013).

The reduction in cost is due to that the software can facilitate effective site planning to enhance efficiency as well as reduce the rework to save time and money (Aibinu & Venkatesh, 2014; Al Hattab & Hamzeh, 2015; Azhar, 2011;

Chan et al., 2019; Fazli et al., 2014; Masood et al., 2014; Wc, s. f.; Wong et al., 2009; Yan & Demian, 2008) for the construction, even though the most interesting plan for the financing is that a better cost estimation could be done. BIM can generate some data including the quantities of materials automatically increasing the accuracy of the cost estimate (Azhar, 2011; Dakhil & Alshawi, 2014; Fazli et al., 2014; Ku & Taiebat, 2011; G. Lee et al., 2012; Masood et al., 2014; Wong et al., 2009). This estimation anyway needs to be supported by costs estimators, which provide a subjective view (S.-K. Lee et al., 2014) because even though theoretically all the needed information can be obtained from BIM, practically, unless all the information is included within BIM, help from the estimator is needed for searching for appropriate work items. The searching of these work items can be done by the engineers so that the cost estimation is more accurate with the use of ontological approach and semantic technology combined with BIM, which is more, makes it possible to automatize the cost estimation by automatizing the search of suitable work items for the building elements and materials (S.-K. Lee et al., 2014).

One of the best-known types of finances that could be analyzed through BIM models is the PPP partnership. This finance model allows for huge projects to go ahead. Through the years this type of financing has evolved until today, as investigated by (Cui et al., 2018). 6 are the main research topics on which the scientific community is focusing. From 1990 to 2000, the researchers attempted to summarize the main features of the PPP structure by analyzing the cost, concession, equity structure (Cui et al., 2018; Tiong, 1995), and contracts. From 2000 onwards the

focus changed to detailed issues in the financial package. Several authors published different theories and measurement methodologies, simplified model for build-operate-transfer (BOT) projects (*Bakatjan et al., 2003*), genetic algorithm (GA) based model (*N. Smith et al., 2004*), etc. The popularization of PPP finance models turned to be important. Nowadays, the term sustainability has become presented as a simplified model, which combines a financial model and a linear programming model, to determine the optimum equity level for decision-makers at the evaluation stage of a BOT project.

(*Cui et al., 2018*) found that the economic viability and value for money (VFM) are some of the most relevant topics that nowadays are also closely investigated along with stakeholders' satisfaction, and the economic environment. Many tools and techniques have been provided by the researchers through the last two decades, even though, over the past few years the focus of studies about a PPP's economic feasibility has shifted from the calculation of evaluation indices of traditional methods of economic feasibility assessment to the improvement of evaluation methods as well as the establishment of brand-new evaluation systems. (*Cui et al., 2018; Fantozzi et al., 2014*) developed and analyzed a public sector comparator (PSC), for which the valuation of risk, borrowing costs, and bid costs were established as the key parameters, which were taken from the ones that (*Cui et al., 2018; Heald, 2003; Pitt et al., 2006*) identified as key factors increasing VFM. However, the VFM assessment should be extended so that long-term social and sustainable impacts are considered. The evaluation

of the stakeholder satisfaction from a financial perspective has been done through many methodologies, quantitative and qualitative approaches, stakeholder consultation and management responsibilities among critical stakeholders (*Cui et al., 2018; De Schepper et al., 2014; Henjeweale et al., 2013; Sohail et al., 2004*), since the stakeholder satisfaction influences the suitability of a project for PPP as well as their collaboration and performance influences the application conditions.

Risks are also part of the PPP structures, being the ones that impact cost financing, construction, and operation cost overruns (*Cui et al., 2018; Ibrahim et al., 2006*). Risk cannot be ignored, they can be minimized, shared, transferred or accepted (*Taroun, 2014*). Successful PPP imply unique strategies and capabilities in risk management (*Cui et al., 2018; Tiong, 1995*). Public and private should be assessed separately due to the complex nature of risks. Risk register matrix, a fuzzy synthetic evaluation approach (*Cui et al., 2018; Effah Ameyaw & Chan, 2013; Xu et al., 2010*) or Monte-Carlo approach (*Alonso-Conde et al., 2007; Chang & Ko, 2017; Cui et al., 2018; Wibowo & Alfen, 2013*) are some of the tools for the risk assessing. In a general terms, not only for PPP, the Probability–Impact (P–I) risk model is prevailing and risk is usually assessed through assessing its probability of occurrence and impact (*Taroun, 2014*).

The P-I model has been proposed to be enhanced several times by adding new measurement parameters that allow for evaluating beyond the variances the traditional model of variances of costs or duration. More measurements that are capable of reflecting the true nature of the risk and the experience of the

management team in handling risk, the complexity of project systems that may affect risk assessment and the interaction between project risks are proposed by (Taroun, 2014),

On the other hand, the allocation of the risks between public and private is considered as one of the principal factors in evaluating and creating VFM. (Alonso-Conde et al., 2007; Cui et al., 2018) introduced the so called “real-options” for this evaluation. A correct allocation of the risks is included among the critical success factors (CFS). Many groupings and definitions of key terms have been done, but finally, (Chou & Pramudawardhani, 2015; Cui et al., 2018) set up five groups, stable macroeconomic environment, shared responsibility between public and private sectors, transparent and efficient procurement process, stable political and social environment, and judicious government control.

When speaking about construction project risks assessment (Taroun, 2014), like in any other type of project, subjectivity is present due to the perception of risk and the probability parameter included in the assessment. In addition, within the construction, the experience and judgment of the individuals are the basis for risk assessment. As this subjectivity cannot be removed, FST was introduced as a viable alternative for handling subjectivity in construction risk assessment. Complexity in the projects is also present and cannot be avoided, and so because of that, AHP was introduced providing a systematic approach to structuring risk assessment problems by providing a logical approach for assessing risk impacts and allocating importance weighting. Furthermore, sophisticated DSSs are

being devised to facilitate analytical and statistical tools and to handle the growing complexity of risk assessment. This more realistic assessment allows for an also realistic project risk level determination against the current limitations.

Whereas the tools exist, there is still a lack of agreement for a common scale of measuring risk impacts. Yet risk cost is being used as a risk measurement impact scale, the output remains to be the sum for covering the risk instead of being the risk impact on project objectives, what could provide far from the actual methods, a quantitative evaluation. The risk has turned from being considered as an estimation variant towards as a project attribute.

Financing is a very concerning topic within the construction sector due to the complexity of this type of projects. (Baker et al., 1998; Taroun, 2014) found that for financial risk assessing expected money value (EVM) was the main tool along with break-even, scenario and sensitivity analysis not only in the construction, but also in the Oil and Gas industries, supporting the intuition, experience, and the judgment of the individuals. On the other hand, risk management is believed to benefit particularly in project budgeting and contingency estimation.

- **Financing related tools from several sectors**

Risks are uncertainties associated with any form of financing (Kou et al., 2014). Many types of analysis could be done for analyzing the financial data in search of risks in advance like the methods found for construction or business intelligence (Gennari et al., 1989; Kou et al., 2014). These analysis also help to minimize the defaults, and to support better decision

making (Kou et al., 2014), 'risk' is the cornerstone in decision making process (Shahriar et al., 2012).

In a more general manner, it can be said that between the supervised and unsupervised analysis methods, the unsupervised methods bring the opportunity to find underlying structures in unlabeled data while providing labelled data for supervised methods (Kou et al., 2014). Clustering algorithms is one of the most used unsupervised methods. MCDM was proposed by Rokach (Kou et al., 2014; Rokach, 2010) as a way of evaluating clustering algorithms, a difficult task since the lack of objective measures (Kou et al., 2014).

The clustering algorithms provide solutions that then need to be evaluated using performance indicators. (Kou et al., 2014) carried out an analysis for 3 financial risk data with 6 different clustering analysis, which were afterwards measured through 11 performance indicators. These indicators belonged to an internal and external collection, even though relative test is a third option of measurement, a more subjective method based on the needs of the user. Finally, 3 MCDM methods were used to rank the clustering algorithms. (Kou et al., 2014) found out that no algorithm can achieve the best performance on all measurements for any data set and it is necessary to utilize more than one single performance measure to evaluate clustering algorithms. However, the repeated-bisection algorithm provides the best solutions.

Another tool for risk assessment is presented by (Shahriar et al., 2012) based on Oil and Gas (O&G) pipelines. Pipelines all around the world have faced issues due to different problems, leading them to extensive maintenance

supposing these sometimes-heavy financial liabilities. Though this issue is not exclusive to this industry but can happen in any. Fault tree analysis (FTA) and event tree analysis (ETA) are two graphical methods used to perform risk analysis. "Bow-tie" is an approach integrating both FTA and ETA to represent causes, threats, and consequences.

Every risk event is usually considered independently, but this is not a completely correct approach. Besides, within this type of assessment, the subjective part added to the fact that an individual is doing the assessment and probabilities are involved needs to be sorted out some way. Fuzzy Set Theory (FST) could be included to handle this aspect of the analysis (Shahriar et al., 2012). The aim is to be able to handle data and model uncertainties together, qualitative, and quantitative data. Once the likelihood of the risk is obtained by the FTA and ETA, the introduction of the utility value provides the way to evaluate the consequences of the corresponding risk. Using the fuzzy utility value (FUV), which includes fuzzy synthetic evaluation (FSE) and fuzzy rule based (FSB), the subjective part is also included. But what is more, the possible social, economic, and environmental consequences are also considered.

Evaluating financing includes not only evaluating risks, but predictive models for bankruptcy and credit soaring can be done by financial institutions for avoiding further financial issues. Machine learning is among some of the techniques that can be used for that purpose (Lin et al., 2012), like soft classification techniques. Stock market prices are another prediction to be done for a good financial evaluation since they are one of the most important indicators

of a country's economic situation (Göçken et al., 2016; Perwej & Perwej, 2012). However, this type of analysis is far from being exact, following the nature of a prediction, they are also characterized by nonlinearities, discontinuities, and high frequency multi-polynomial components due to the high number of factors with which they interact. This predictions can be based in technical indicators such as simple moving average of close price, momentum close price, etc. (Göçken et al., 2016; Hadavandi et al., 2010). The relationship between the indicators and the stock prices can be done with models, among which Harmony Search (HS) based Artificial Neural Network (ANN) were found by (Göçken et al., 2016) to be the dominants, being also possible to build hybrid model using more than one model as investigated by (Göçken et al., 2016). Within these types of models, the critical parameters are found to be by (Göçken et al., 2016) the number of input variables and the number of neurons.

In addition, stock markets are highly influenced by the crude oil, a contagion phenomenon was found by (Wen et al., 2012) although not the same countries followed the same pattern of relation. To be able to determine the contagion grade allows a better risk management and policy making (Wen et al., 2012).

6. Results

- **Project management standards**

The study done for the PMBOK Guide Seventh Edition, IPMA ICB 4.0, ISO21500:2012, PM2 guide and PRINCE2 training manual standards shows that even though the standards aim to support the same role, the bases of each of them differs from one to another. Just IPMA ICB 4.0 covers an

area exclusively for financing, while the rest do provide some insight into the financial management. Excluding IPMA ICB 4.0, lack of methodology is provided within the rest of the standards, and lack of agreement is found between all of them. References to cost and risk are included somehow in all the standards.

On the other hand, the five standards do cover a wide range of responsibility areas and different activities for the ongoing of a project from a project management point of view, and all of them are related between them. Finally, not all the standards do provide the how to of an expected activity to be developed by the project manager apart from the what, what also affects the aspects related to the financing covered by each of the standards. In this way, just PMBOK Guide Seventh Edition and PM2 guide are the only standards giving the how-to part.

- **Construction Extension to the PMBOK Guide**

The Construction Extension to the PMBOK Guide, which is as well as what to as a how-to guideline, includes not just the supposed general responsibilities for a project manager, but 4 financial management responsibilities areas are pointed out for a project manager. 3 major processes (planning, controlling, and closing) are included within the financial management area. For each process, also called stages in, inputs, outputs, and tools and techniques are provided.

In the planning stage the selection of the sources and the need to obtain and maintain them are mentioned. Factors like the economic environment and risks need to be considered, as well as the taxes and their deductibility in some countries. The project financial plan shall

include all the financial requirements and the plan to obtain and manage them.

The control of the financial management assures the ongoing within the budget. Audits, either internal or external, the regular analysis of the cash flow data, reports, experts' advice, or ex-post evaluations helps to measure the effectiveness comparing the achieved benefit against the planned additionally to foreseen over costs so that measures can be taken. Finally, administration and records provide a way to administrate financial information.

- ***Scientometric review of the scientific bibliography***

This systematic review performed the statistical analysis and mapping of the bibliographic data available in the research of financing of projects. This analysis identified the sources of publications (journals) that published the most documents, the most often-used keywords in publications, the documents and researchers with the highest citations, and the nations vigorously engaged in finance of projects research. According to the assessment of keywords, risk management has mostly been researched to avoid further financial issues while the project is happening. For example, in the renewable energies sectors, where the accessing of finance is not so easy due to the long-term returns and high risks included in the projects, a proper risk management before granting finance from the banks is one of the measures proposed by the authors. In addition, the literature and their linkages based on citations were used to identify the highly committed and participating nations based on publication count. The graphical representation and quantitative analysis of the participating

countries and researchers will help young scientists in forming scientific partnerships, establishing joint ventures, and sharing advanced methods and concepts. Scholars from countries concerned with expanding the research on the finance of projects can collaborate with professionals in the discipline and benefit from their expertise. After assessing keywords in the subject topic using the scientometric analysis method and reviewing the most relevant literature, this study highlighted and discussed the present-state applications of tools and techniques of finance of projects and the limitations associated with the risks inherent to some projects.

7. Conclusions and new methodology proposal

This study's purpose was to undertake a bibliographic analysis of the main standards that serve as guidelines for project management while complementing it with a standard for the construction sector. Besides, a scientometric assessment of the available literature for the last decade (2012-2022) on finance of projects research to evaluate the current state of the scientific investigations and the latest progress in the field was done. The database Scopus was searched for 2559 related articles and reviews, and the records were evaluated employing the VOSviewer application. The following conclusions were obtained from this study:

- PMBOK Guide Seventh Edition provides information through the functions, performance domains and principles, as well as methods and artifacts linking them to the performance domains where they can be used, for various factors like costs, risks, taxes, and control related to the financing

activity, even though clear guidelines are not provided.

- IPMA ICB 4.0 covers financing through the competence domain within the area practice, Finance (practice 7). Competence is also related in the standard to other competences which with it interacts, that are located within the practice, perspective, and people areas. Knowledge, skills and abilities, key competence indicators and measures for the development of the activity are provided.
- ISO21500:2012 does not provide a subject group or process that is focused on finance. Processes for costs and risks factors are included in the standard within the planning, implementing, and controlling process groups. Primary inputs and outputs are also available for each process.
- PM2 guide unlinks the financial management from the project manager role, even though covers the documents related to the funding decisions by means of when they are supposed to be developed and by whom. In the monitoring and controlling stage activities related to finance are given, apart from tools and techniques with templates.
- PRINCE2 training manual does not provide detailed specialist aspects even though the method helps to keep the project within the business case, document very detailed in the standard and which is part of the executive responsibilities unlinking it from the project manager role. References to risks and benefits management are also provided.
- Just only the IPMA ICB 4.0 includes the activity of finance as an entity, although it does not provide the project manager with tools or techniques to be used for the development. PMBOK Guide Seventh Edition and

ISO21500:2012 covers some of the aspects that affect and are intrinsic to the finance of projects, even though it does not do it in a clear manner with guidelines to be followed. Methods and artifacts that could help in the construction of a finance plan are given but one more time, they are not provided clearly related to the activity. ISO21500:2012 provides just two groups of processes clearly related to the finance of projects with inputs and outputs, but no guidelines for how to develop those inputs and outputs for each process are given. PM2 guide serves the project manager with inputs and outputs that are related to finance even though the standard finds out that financial management is not part of the duties of the role. PRINCE2 training manual provides a very detailed description of the business case document, but once again, the standard unlinks the duty of the development of the business case and the financial part of the project from the project manager role. IPMA ICB 4.0, ISO21500:2012 and PRINCE2 training manual are what to guides, while PMBOK Guide Seventh Edition and PM2 guide are a what and how to guide.

- The Construction Extension to the PMBOK Guide provides a complete financial management methodology, that with some adaptations adding tools and techniques provided by other standards for some aspects depending on the type of project to be developed, can be extended into any other sector, and used it as guideline for the financing of projects.
- An evaluation of publication journals, including articles and reviews on financing of project research, revealed that “Energy economics”, “Journal of construction engineering and management”, and “International journal of project management” are the top

three sources, with 106, 79, and 74 publications, respectively. In terms of total citations, the top three publishing sources are “International journal of project management” with 4585, “Energy economics” with 3208, and “Journal of construction engineering and management” with 1926 citations.

- Assessment of keywords on the topic research field reveals that risk management, project management, risk assessment, financial risk, and risk are the five most often occurring terms. The keyword analysis found that risk management has mostly been researched in several sectors searching for tools and techniques to enhance the identification and assessment of them.

- Analysis of researchers found that just 6 authors had published at least 3 articles on finance of projects research. According to their document count, overall citations, and average citations, the leading authors were categorized. Lefley, F. is the most prolific researchers with 4 publications each, followed by Cheng, M.-Y., Tran, D.-H., Sousa, V., Almeida, N.M, and. Dias, L.A with 3. In terms of total citations, Sousa, V., Almeida, N.M, and. Dias, L.A. lead the field with 209, Cheng, M.-Y. AND Tran, D.-H. are second with 79, and Lefley, F. is third with 20 overall citations in the present research domain. In addition, when the average number of citations is compared, the authors might be ranked the same order as for the citations with 70, 26 and 5 average citations respectively.

- An assessment of published documents containing data on finance of projects for the last decade revealed that Fernandes D. (*Fernandes et al., 2014*)’s work “Financial literacy, financial education, and downstream financial behaviors” received 757 citations. Bryde, D. (Bryde et al., 2013) and Kou,

G. (*Kou et al., 2014*) received 728 and 588 citations for their studies, respectively, and were among the top three. In addition, Škare M. (*Škare et al., 2021*)’s work “Impact of COVID-19 on the travel and tourism industry” received the most citations for the last three years, 265 exactly.

- Based on their engagement in finance of projects research, the top countries were evaluated, and it was concluded that only 35 countries published at least 20 documents. The United States, China, and United Kingdom presented 527, 498, and 286 documents, respectively. In addition, United States received 9623 citations, followed by China with 7097 citations, and the United Kingdom received 6835 citations.

- Since construction sector projects are large and long-term projects, their financing is a critical aspect of their success. These projects are turning more complicated while the time passes by, and therefore, researchers are very active in the investigation of the field regarding them. The overall management of the project while with the introduction of BIM methodology has been improved, allowing it with the help of the ontological approach and semantic technology for a more exact cost analysis. PPP structures are some of the most widely used financed structures among the construction, for which various types of evaluation methodologies have been introduced in the last years like the VFM.

- Risk assessment is one of the main factors concerning financing within large investment projects in any sector. Many tools can be found for the assessment like Monte-Carlo approach or risk register matrix, being the probability impact (P-I) assessment the most used one. The decrease of the

subjectivity factor and the allocation of the risks when managing them are some of the topics that still need to be improved, for which some techniques like FST and “real options” respectively have been introduced the last decade. GCGS was a technique proposed for the renewable energy technique to reduce the risks in these types of projects attracting in this way banks to invest in the technology. MCDM for evaluation of clustering algorithm, or the “bow-tie” approach are other proposals coming from several sectors for risks management.

- Renewable energy is the future of production or green energy for a sustainable world. Finance access is the main issue for the technologies due to the long-term return and high risks associated with the projects. Besides, financing actors influence to a high degree in the development of the innovation, making it possible to avoid it in grand manner with proper financing policies. Last year’s sector trends in financing and the characteristics of the financial actors should be included in the development of the policies. The private cost of capital is another calculation to introduce when planning the financing for a cost-efficient project.

- Predictive models for evaluation of bankruptcy and credit soaring by financial institutions can be done by means of soft techniques within machine learning. Stock market prices predictions can be done since they show the economic state of a country with Harmony Search (HS) based Artificial Neural Network (ANN) that help to make them more accurate reducing the subjective part.

After project management standards review and a scientometric based review on finance of projects was done, it was noticed that the current state of research

is not sufficient for a clear financial management process to be followed including the steps with the tools and techniques that a project manager of any type of project should followed. Based on the benefits of a proper finance decision based on a well-planned financial structure, it is recommended that a thorough investigation needs to be carried out into their practical applicability in any sector. A proposal for a financial management methodology is given based on all the information gathered so far.

New methodology proposal

Many different financial management methodologies have been found through the literature review, but there is a lack of agreement referring to the steps to be followed to be able to develop a financial management plan. The stages for the financial management process could be the same as the ones described for a project, which are initiating, planning, implementing, monitoring, and closing, and that can also be connected between them. Anyway, it is not a separate process but another competence of the project management to be developed within the project and therefore, a new methodology should be focusing on specifying the inputs and outputs towards the finance for each stage of the project already defined. From this point forward funding will refer to the ability of an organization to finance the project with internal resources, while finance refers to the ability of an organization to finance the project externally.

- ***Initiating***

The funding availability is a strong variable for choosing a development approach, so it needs to be defined in early project stages. It does not only affect the development approach, but

also decisions towards the product and the investment. At the end of the initiation stage, a project charter is obtained. The inputs for obtaining the project plan are the business case, the project mandate, and the statement of work. A project management plan can also be included.

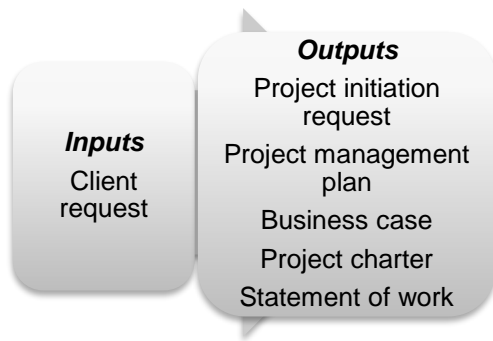


Fig. 9– Initiating stage financial management outputs and inputs

- **Planning**

At the end of the planning stage, a project work plan is obtained. The inputs for obtaining it are the project charter, the business case, the business initiation request, project management plan and contract requirements.

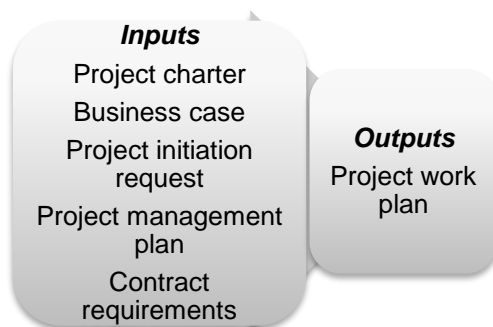


Fig. 10– Implementing and controlling stages inputs and outputs

- **Controlling**

During the controlling stage, project status reports, project progress reports and change requests are obtained. The

input for obtaining them is the project work plan.

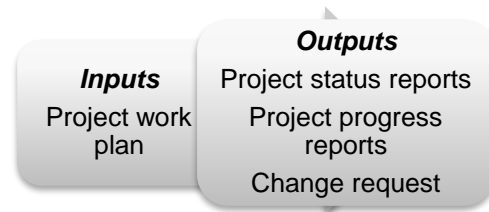


Fig. 11 – Implementing and controlling stages inputs and outputs

- **Closing**

At the end of the closing stage, lessons learned are gained. The inputs for obtaining them are the project status reports, contract requirements and the project work plan.

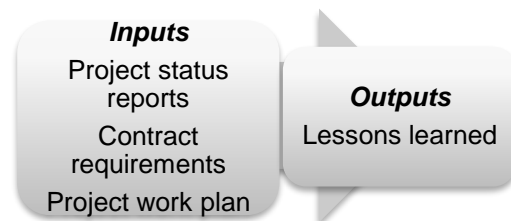


Fig. 12 – Implementing and controlling stages inputs and outputs