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Project Governance as a systemic model of project organization: A literature review

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Contents

Abstract

There are various definitions of Governance in the Project Management literature. Major project management institutions, such as PMI and IPMA, provide their own definition of project governance. The most established standard is ISO 21500. What all the guidelines of the various institutions have in common is the lack of a quantitative and at the same time systemic governance approach, in other words a holistic method that can support a project throughout its entire life cycle. The aim of this research is to make an analysis of the scientific literature in order to find a method that is able to generate data by operating at a high level perpective.

The first chapter of the thesis takes up the literature on engineering, economics and decision science, which dealt with governance in projects from different perspectives. The theories behind governance are presented to describe the causes of certain dynamics within an organisation or project. Such theories, although purely theoretical, are the necessary starting point for any project governance approach.

The second chapter aims to identify the current state of the art in this direction through a bibliometric analysis of the scientific literature. This study attempts to map the global research on quantitative and systematic models that can support project governance. Network analysis is used such a research tool for the construction of bibliographic networks to identify key elements within the literature. The reflection on this literature and on the cognitive needs of the thesis lead us to identify Social Network Analysis as the appropriate project governance analytical tool to find quantitative data through the use of networks of relationships.

The third chapter presents Social Network Analysis in detail arguing that studies of SNA provide interesting findings in the possibility to link the local actions and intentions of agents to the global behavioral patterns of the systems of which they are a part. In this way, the model of the SNA is illustrated and then the methods of collection and elaboration of the information are illustrated, through the presentation of any metric able to capture salient aspects of the relations.

Introduction

We can define project-based organisation governance as the set of principles, rules, institutional and structural choices, practices and systems that are conceived and used to foster project-based work in a company and which, together with any necessary process governance logic, allow the interests of the company's various stakeholders to be reconciled.

Governance, applied at the corporate level, affects projects through its impact on the behaviour of people. Thus, it needs to be implemented through a framework that guides managers in their daily work of decision making and action taking (Müller R. , 2009).

The literature on project governance models or guidelines addresses different contexts, such as (Joslin, 2019):

- risk allocation (Abednego and Ogunlana, 2006),
- frameworks for analyzing the development and delivery of large capital projects (Miller and Hobbs, 2005)
- Governing the project process (Winch, 2001)
- Mechanisms of governance in project organizations (Turner and Keegan, 2001)
- Normalization of deviance (Pinto, 2014)
- Stakeholder management (Aaltonen and Sivonen, 2009)
- Project Governance Roles (Turner, 2008)
- Governance in project-based organizations (functional, matrix, or projectized) (Müller et al. 2014).

Although the field of application of project governance is constantly growing and the approaches proposed are manifold, what seems to be missing is a systemic vision. Each of these frameworks seems to be contingent on solving a specific problem, losing the overview of the whole system. (Müller R. Z., 2016) points out in this regard “to that end the studies provide an interesting ‘patchwork’ of different approaches, but do not join the findings into a wider framework which identifies their commonalities and differences across approaches.”

This problem is exacerbated by the fact that projects and their dynamics are subject to increasing complexity, which makes the use of standard governance approaches in support of projects insufficient. The fact that projects have become increasingly complex is well attested (Baccarini, 1996).

The state of the art of project governance is universally recognised in (Müller R. , 2009), where the interest of an organisation is to manage a project with the aim of optimising its strategic objectives in line with the programme and portfolio. This view, while correct, does not emphasise the emerging complexity of projects and becomes unlikely to be effective on projects delivered in complex environments, where governance needs to be transformed from a project perspective to a system perspective (Locatelli, Mancini, & Romano, 2014).

One of the problems which arises when attempting to describe the behaviour of a project from a holistic point of view is the definition of the relationships which constitute it. These relationships have different characteristics and are the first point to be considered.

The natural way of thinking of the human being about relationships is in a linear causal form. This means that each cause A tends to be associated with an output B. Traditional operational research interfaces with a problem using mathematical models that take into account a few measurable variables, which are related in a linear way. Using linear approaches is the simplest and most intuitive way of describing a phenomenon, however, the increasing complexity of projects makes these approaches more and more limiting. Most advanced models manage complex systems replacing linear causality logic with circular causal effects logic, where an event A can cause B but at the same time B can cause A.

(Kapsali, 2011) states that conventional project management approach treats projects as closed boxes and rely on predefined frameworks to manage them, leaving few flexibility and deviations from the project plan. Most projects are performed solely with a linear and deterministic view, using tools such as CPM that tighten the activities in a rigid pattern. Traditional approaches such as precise planning are less effective for complex projects because they take little account of the interaction between activities. These approaches do not help implementation projects to work well, as they inhibit innovation and communication across boundaries and limit managerial action to manage change. Rather, project management should be concerned with equipping the team to cope with challenges rather than giving top managers a platform to monitor progress (Kapsali, 2011). Complex projects are characterised by boundaries that change in response to a changing environment, consequently the system to manage projects needs to be unique to those using it and the environment it is working in (Sheffield, Sankaran, & Tim Haslett, 2012).

In most cases, projects carried out in complex contexts are associated with a considerable degree of uncertainty, but also with a mix of joint organisations and subcontracting (Locatelli, Mancini, & Romano, 2014). Consequently, it becomes impossible to manage all the phases and all the individual elements of the project with a strictly hierarchical method.

The necessity of moving from a project-based governance model to a system-based model descripted above is bringing to light a number of new approaches and methodologies that increase the chances of success of a project in a holistic way. The aim of such approaches is to transform the governance from project-governance to system-governance, improving the performance of projects delivered in a complex environment.

Consequently, based on these premises, the research question we want to examine is:

Can a governance quantitative method contribute to the understanding of the behavior of projects?

Chapter 1

Governance provides a framework for establishing the boundaries of managerial action, defining the organisation's objectives and how they should be achieved, and the processes that managers should use to administer their areas of responsibility.

In the field of project management, each association has developed a certification proposal regarding Governance.

PMBoK (Project Management Body of Knowledge) is a set of standards and solutions concerning project management, collected, and published by members of PMI (Project Management Institute). The PMBoK Standard is a set of well known and accepted procedures applied in project management. PMBoK defines Governance as “the alignment of the project with stakeholders’ needs or objectives”. Furthermore, “it provides a framework in which the project manager and sponsors can make decisions that satisfy both stakeholder needs and expectations and organizational strategic objectives or address circumstances where these may not be in alignment […] Project governance is defined by and is required to fit within the larger context of the program or organization sponsoring it, but it is separate from organizational governance”.

IPMA (International Project Management Association), the oldest project management association founded in 1965 in Switzerland, defines governance as a framework to “align with structures and processes through value systems, roles and responsabilities, processes and policies established in an organization to ensure that the project achieve their objective and strategic corporate goals”.

PRINCE2 includes method of project management based on experience of project managers from the Anglo-Saxon countries. In this methodology governance “ensures that an organization’s project portfolio is aligned to the organization’s objectives, is delivered efficiently, and is sustainable. Governance of project management also supports the means by which the corporate board and other major project stakeholders are provided with timely, relevant and reliable information”.

ISO (International Organization for Standarization) is the world federation of national normalization units. An ISO is a document that considers the latest developments in international project management and does not deny or cancel the use of other existing standards. It is therefore configured as a flexible tool to support differences between standards. As such, it is a document that summarises a set of universally accepted project management principles. The works connected with preparation of international standards are usually done by technical committees of ISO. Each member organization interested in the given field can have their representatives in the suitable committee. International government and other organizations connected with ISO can participate in its works. The international standard on social responsibility, ISO 26000, defines organizational governance as "a system by which an organization makes and implements decisions in pursuit of its objectives."

The ISO 21500 is the first of a family of ISO standards for portfolio, program and project management, and Governance. ISO 21500 is a standard in which 37 countries have participated and where PMI and IPMA have played a major role in development.

Despite all these guidelines, governance is still considered a 'soft' concept, as it is difficult to relate it to a pragmatic and quantitative concept. It has been observed, for example, that even among project management practitioners the concept is not uniformly clear. In a review of 2020, “What do project management practitioners think governance is?”, practitioners were interviewed, and their answers were subsequently analysed, finding that there is confusion over what governance actually means. However, “participants seemed able to sense the meaning of governance but not quite distil or determine or verbalise its essence. This is perhaps symptomatic of the way we human beings come to understand and form concepts; by experiencing different aspects of them until we feel we can appreciate a coherent whole” (McGrath & Whitty, 2020).

As mentioned, Governance takes a wider spectrum of definitions, which have in common the regulation of the following processes (Müller R. , 2009):

- *Definition of the objectives of an organization*. Based on the organisation's strategy, or the specific contribution an organisation can make to achieving the strategic objectives of a company.
- *Provide the means to achieve those objectives*. It concerns the provision of necessary resources (in the form of human resources, budget, time and so on) for the members of an organisation to enable them to fulfil their responsibilities.
- *Controlling progress*. It addresses the need for oversight to control the appropriate use of the resources provided; the application of suitable processes, tools, techniques and quality standards to create the organisation's products or services; and the control of the necessity or marketability of the organisation's products and services over time.

Governance Theories

Project Governance is a fairly recent concept that is becoming ever more relevant to the project success, in particular for large and complex projects. One of the key contributions in this field of research is certainly (Müller R. , 2009), where governance is approached at project level and at organization level. In particular, he suggests a model linking governance among project management, program management and strategic management.

A project, as a temporary organization, needs governance (Turner, 2008). For more than 50 years, organization and management theory have been influenced by governance theory and the idea of organizational fit. In the context of project and programme management, governance theory seeks to explain, among many other things concerning the nature of organisations, both how the integration required to achieve project objectives varies and how the structure of governance varies according to the environment in which it operates and the technology used.

In the field of project management research, comparatives are made mainly through theoretical lenses, and, regarding project governance, such comparatives can be complexity theory, agency theory, stewardship theory, critical point theory, prospect theory, contingency theory, and complex adaptive systems theory (Joslin, 2019). These theories provide the rationale for the human behaviours that project governance aims to regulate and are the basis for more complex approaches. Such theories are not necessarily mutually exclusive and indeed address the dynamics of an organisation from different perspectives. The main trade-offs are between Agency and Stewardship theory and Stakeholder and Shareholder theory.

A rationale behind the use of general management theories to ground theories of corporate governance is to provide a framework for addressing, understanding and managing the issues associated with poor corporate and project governance (Hirschey, Kose and Anil 2009).

Theory	Description	Key Authors
Agency Theory	Two parties are involved, the principal and the agent, both perceived as rational economic actors acting in a self-interested way.	Mitnick (1973), Jensen and Meckling (1976)
Stewardship theory	Actors (typically managers) are administrators who find more benefit in remaining aligned with the goals of their principals than with their own goals.	Donaldson and Davis (1991)
Transaction cost economics	Organizations adapt their governance structures to achieve the lowest transaction costs to produce a product or service.	Williamson (1979)
Stakeholder theory	Governance must be defined to provide an overall benefit from the perspective of all stakeholders rather than just shareholders.	Donaldson and Preston (1995)
Resource dependency theory	Managers must engage in transactions with other actors and organizations in its environment in order to prioritize, acquire, and facilitate the utilization of resources aligned to organizational objectives.	Pfeffer and Salancik (1978)
Contingency theory	Each independent variable has an impact on another dependent variable depending on some third moderator variable. The optimal course of action is contingent upon the internal and external situation.	Donaldson (2001, p. 5)

List and Description of Governance Theories: overview of the core literature (Joslin, 2019)

Shareholder Theory

The Shareholder Theory of corporate governance assumes that the main purpose of an organization is to create wealth and value for its stakeholders, such as maximizing shareholder return on investment (ROI). Therefore, structures such as contracts, processes and policies to assure managerial action must be always in the best interests of the shareholders.

The resulting consequence is an organisational value system that prioritises the shareholders' interests over stakeholders' interests, leading to a tight adherence to quantitative measures of financial performance at the expense of more qualitative objectives, such as employee welfare, ethical standards and good relations with the society in which the company operates (Müller R. , 2009).

Difficulties with this approach arise in managing a diverse set of stakeholders in alternative governance structures and the need to direct managers' attention to a single bottom line result.

From a project perspective, portfolio managers generally operate primarily on behalf of a company's shareholders, so they take a shareholder perspective when deciding whether to accept projects. It is still under investigation whether there is a causality between the possible poor performance of these companies due to their narrow focus on financial results, or if an existing lack of performance causes this focus on financial measures.

Stakeholder Theory

Stakeholders are defined as all those who have an interest in the organisation; namely, they have something to gain or lose through the organisation's actions. Stakeholder Theory takes the wider social responsibility of organizations into account. A company is therefore a stakeholder system, operating within the wider host society, which, in turn, provides the legal and market infrastructure for the company's activities (Müller R. , 2009). Consequently, the purpose of the firm is to create wealth and value for its stakeholders.

Corporate governance, especially through board characteristics and internal control and risk management is argued to be a good mechanism to coordinate and reduce the conflict of interests among stakeholders (Ghofar & Islam, 2015)

Stakeholder theory implies that the purposes of an organisation should be carried out balancing the conflicting interests and claims of different stakeholders, including managers, employees, suppliers and society itself. Traditional financial targets such as return on assets (RoA), return on sales (RoS), revenue growth over an extended period of time such as five years are among the main quantitative performance metrics. No less important are measures of corporate social performance such as the organisation's reputation, the attractiveness of the organisation as an employer and the generation of goodwill from the society in which it operates.

However, this is opposed to companies governed according to the Shareholder Theory which usually focus on short-term financial results.

Transaction Cost Economy

TCE implies that organizations achieve the lowest transaction costs to produce a product or service and adapt their governance structures to achieve this. TCE can be loosely characterized by the classic make or buy dichotomy (Müller R. , 2009). In this case, it is used to justify a decision to make a product internally or to buy it from the open marketplace. Also, TCE addresses questions such as who should sit on the company's board or what is the right balance between debt and equity financing. All problems relate to how a complex contractual relationship should be governed to avoid waste and create transaction value (Mikko Ketokivi, 2017)

TCE attempts to describe and understand two types of heterogeneity. The first type is transaction diversity, i.e. what are the relevant dimensions with respect to which transactions differ from one another. The second type is organisational diversity, i.e. what are the relevant alternatives in which organisational responses to transaction governance differ from each other.

In projects, TCE explains the need for different governance structures for different projects along the need for different contracts when either buying a product in the market or making it within the organization (Müller R. , 2009).

Contingency Theory

It is an organizational theory that claims that there is no single best way to manage and structure an organization. Contingency theory can be defined as a systems theory, as it sees organisations as 'open systems' that react to their environment in order to survive, adapting their structure (morphogenesis) and their dependency patterns. The basic assumption is that the change in the effect of one variable (an independent variable) on another variable (a dependent variable) is dependent upon a third variable (the moderator variable) (Donaldson 2001, p. 5).

The supporters of this perspective argue that no project can be studied comprehensively without considering its context: the congruence of a project to the external contingencies is a factor influencing the effectiveness of the temporary organization.

Contingency theory is increasingly being applied in research papers. (Joslin, 2019) used it as a theoretical lens studying project success, finding that governance acts as a contingency (moderator) variable. The underlying assumption is that Contingency theory can help explain observed phenomena relating to the influence of environmental factors, notably project governance, on the relationship between project methodology and project success.

A recent bibliographic review, (Hanisch & Wald, 2012), shows that there has been a significant increase in the body of literature of the contingency theory applied to both permanent and temporary organizations since 2005, concluding that different project types would benefit from a contingency theory perspective.

Agency Theory

Agency theory is strongly related to Shareholder theory, which assumes that the company is owned by its shareholders. Hence managers are agents of the shareholders and this allows agency theory to describe the relationships of Shareholder Theory (Müller R. , 2009).

Agency theory is particularly relevant in the field of project management, because “there are many principal-agent relationships in a project supply chain” (Joslin, 2019).

Agency theory is founded on Adam Smith's concept that managers control their governor's money with necessarily less care than how they control their own. The agency theory defines the relationship between a principal (project governor, e.g., sponsor) and an agent (e.g., project manager) where the former commits the latter to carry out some service on his behalf. This presupposes the delegation of certain decision-making powers of the authority to the agent who has more information about the task than the client. This creates an information imbalance between the parties, which could be used by the agent to maximise its own usefulness. In other words, both actors are perceived as rational economic actors who act in a self-interested manner. Therefore, since both parties are maximisers of utility, a potential conflict of interest arises and the principal will assume that the agent does not always act in his interest. Solutions to this conflict of interest typically involve contracts that provide incentives for the parties to act in a compliant manner, as well as more restrictive control structures to monitor the conduct of agents. Both mechanisms result in increased costs.

Properly designed corporate and project governance should minimize the risks and issues associated with agency issues (Joslin, 2019).

Stewardship Theory

Stewardship theory is often considered the contra of agency theory. Stewardship theory is based on a psychological and sociological approach, defining the circumstances where stewards (managers) align their objectives with those of their principals (governors), as collective behaviour in favour of the organisation translates into greater collective utility and consequently also greater utility of the stewards themselves. Governors who adopt a steward perspective rely on the fact that steward's behaviour is collective because it is always aimed at achieving the organisation's objectives and consequently govern this through governance mechanisms based on trust (Davis et al., 1997). Trust as a governance mechanism is indicative of a stewardship perspective, which assumes a pro-organizational and collectivistic attitude of actors in their desire to accomplish the mutually accepted goals (Müller R. Z., 2016). Both Agency and Stewardship theories relate to the behavior of individuals and their dyadic relationships with either their principal, agent or steward (Müller, 2009).

(Müller R. Z., 2016) proposes a governance framework based on size, industry and level of projectification of an organization. Particular emphasis is placed on the organization as an important context variable for a framework where agency theory and stewardship theory are taken as theoretical lenses of two complementary perspectives toward governance. Agency theory is representative of the control governance mechanism toward the utility maximizing behavior of principal, i.e. the governor, and the agent, i.e. the project manager. On the other side, stewardship theory refers normally to trust-based governance mechanisms, having principals that assume collectivistic behavior by the agent and project managers aligning their personal goals with those of the sponsoring organization. The key aspect is that these two perspectives allow to cover a wide range of governance scales. Following the OECD perspective, "in a given project both control and trust are present, but one will dominate as a governance mechanism".

Project Governance in Complex Project Environments

Project Management theory has developed a series of processes and techniques, such as the choice of contracting models, strategic design for project delivery, the process selection of team members, and a huge number of tools. However, along with projects' increasing size, more complex structures, more unpredictable and dynamic circumstances traditional project management theories, methods and tools are no longer sufficient and unadaptable (Li & Lu, 2009). Projects delivered in complex environments are often late, over-budget and provide fewer benefits than what originally expected (Locatelli, Mancini, & Romano, 2014). As projects have grown more complex, there has arisen a need to develop techniques to manage that complexity. Various complex project management frameworks and related research have been developed to deal with the complexity of projects.

"Complexity is that property of a model which makes it difficult to formulate its overall behaviour in a given language, even when given reasonably complete information about its atomic components and their inter-relations" (Vidal & Marle, 2008) .

Complexity is an increasingly recurring theme in a wide variety of fields and is growing at an increasing rate. Historically, there are two main scientific approaches to complexity. The former, commonly recognized as the descriptive complexity domain, regards complexity as an intrinsic property of a system, a view that has incited researchers to try to quantify or measure complexity. The latter, typically referred to as the perceived complexity domain, treats complexity as subjective, as the complexity of a system is improperly understood through the perception of an observer. Consequently, this research aims at suggesting approaches that can create a link between those two traditional visions of complexity.

A project is a temporary and unique effort undertaken to deliver a result. Existing methods have demonstrated their limitations, as they can no longer cope with the increasing project complexity at stake. Limits and deficiencies have been noted in both research and industry with regard to project predictability, as the usual parameters time-cost-quality are evidently not sufficient to correctly depict the whole situation at a given time.

Projects frequently last up to ten years to complete and require a large number of different stakeholders, such as developers, practitioners and customers. In addition, the necessity to react to market changes has brought significant pressure to bear on traditional engineering processes. Not surprisingly, we have grown accustomed to hearing about the difficulties associated with complex projects, cost and schedule overruns, dramatic failures to meet requirements, project cancellations, and so on.

Complex projects:

Complexity theory starts from the assumption that there are large parts of reality in which changes do not occur in a linear fashion (Duit & Galaz, 2008).

Complexity results in a project as well as in an organisational context as a result of multiple interconnected parts that are dependent on each other to complete tasks. Such parts involve social components, like stakeholders, human resources, communications, knowledge sharing, trust and risks. Social context is interactive, with different social elements influencing each other (Lee, Chong, Liao, & Wang, 2018).

In (Shenhar, 2001) projects are classified into four levels of technological uncertainty, and into three levels of system complexity, according to a hierarchy of systems and subsystems. These levels are assembly, systems, and array, and they try to address various levels of complexity from an assembly component with a defined function, to an integrated dispersed collection of systems used to accomplish a common goal. Each type of project requires different organizational arrangements and project processes corresponding to the level of complexity.

(Bosch-Rekveldt, Jongkind, Mooi, Bakker, & Verbraeck, 2011) presented a framework for characterising project complexity in large engineering projects. They analysed fifty factors that lead to complexity in technical, organisational and environmental issues, whereby the factors are split into several categories, subcategories and elements, enabling stakeholders to argue the different aggregation levels and aspects that make a particular project complex.

Geraldi et al. (2011) posited a contingency framework made up of five parameters, which are structural complexity, uncertainty, dynamic pace and socio-political to support individuals and organisations in taking the proper choices in dealing with the complexity of each project.

The vast amount of scheduling methods developed to deal with uncertainty in the activities and project durations, such as reactive scheduling, stochastic scheduling, fuzzy scheduling, proactive scheduling proactive scheduling fail to take into account the logical relationship among the activities (Lee, Chong, Liao, & Wang, 2018)

GAPPS (2007) defines six typical elements in complex project environments. To be defined complex, a project environment should have at least one of the following characteristics (Locatelli, Mancini, & Romano, 2014):

• several key distinct disciplines, methods, or approaches involved in performing the project;

• strong legal, social, or environmental implications from performing the project;

• usage of most of partner's resources (both tangible and intangible);

• strategic importance of the project to the organization or organizations involved;

• stakeholders with conflicting needs regarding the characteristics of the product of the project; and

• high number and variety of interfaces between the project and other organizational entities.

The approaches related to the management of complex systems are many and belonging to different domains, as illustrated in *figure 1*. In this research we will analyse the most relevant aspects that have emerged in the literature regarding their application in a project governance context.

The main themes identified in the context of project governance are:

- complex adaptive systems, which belong to the category of non linear dynamics;
- agent-based modelling, which is part of the macro category of collective behaviour;
- systems theory, which includes system engineering and system dynamics;
- networks and in particular social network analysis, which will be analysed in detail in chapter three.

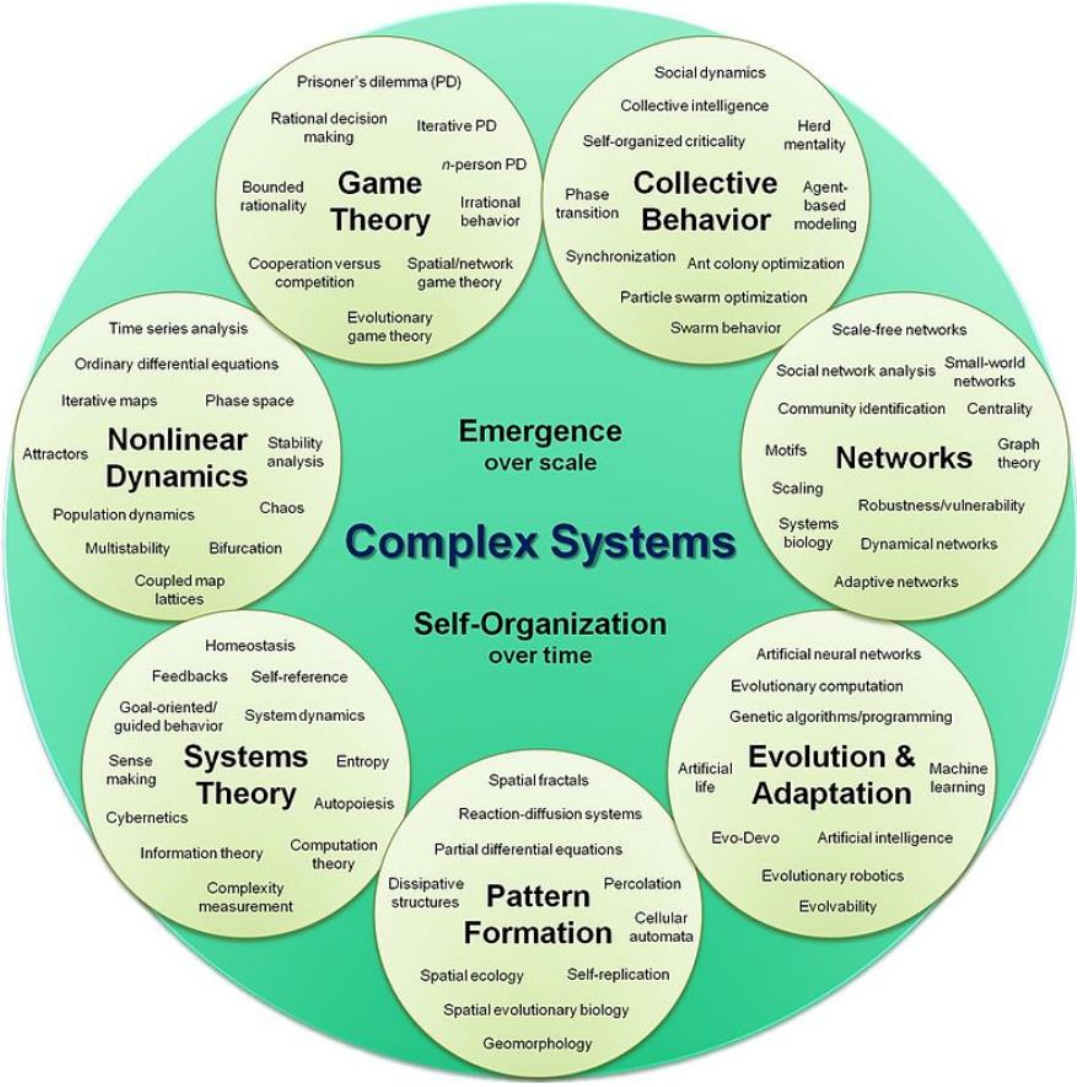


Figure 1. Source: Hiroki Sayama, D.Sc. - Created by Hiroki Sayama, D.Sc., Collective Dynamics of Complex Systems (CoCo) Research Group at Binghamton University, State University of New York

Complex Adaptive Systems

Complex Adaptive Systems is a way to modelling complexity and is used in the field of project management as a theoretical lens to compare complex project behaviour. The idea of adopting a CAS perspective on governance is quite recent and still not very extensive.

Schneider and Somers (2006) define CAS as a multidisciplinary science, compounded by three main inter-related building blocks: non-linear dynamics, chaos theory and adaptation/evolution. A complex adaptive system is a subset of nonlinear dynamical systems with a large number of components, often called agents, that interact and adapt or learn (Holland, 2012). As no central control directs the behavior of agents, self-organization occurs when agents are acting on locally available information about the behavior of other nearby agents (Duit & Galaz, 2008) .Complex adaptive systems are special cases of complex systems, defined as dynamic networks of interactions and relationships (Holland 2006). Using Holland's definition of complex adaptive system attributes, agents within a complex adaptive system are self-similar and numerous, hence are seen as complex.

Complexity science is concerned with complex dynamic systems which are unpredictable and, at the same time, generate new properties and spontaneously self-organise into new structures. As (Olmedo, 2010) points out, organisations are non-linear webs or human interactions, capable of stable and unstable behaviours.

Several natural systems, and increasingly also many artificial (man-made) systems, are characterised by apparently complex behaviours that arise as a result of non-linear spatio-temporal interactions between a huge number of subsystems. Such systems are applicable to a multitude of contexts, including projects. CAS analysis seeks to find shared features and/or formal discriminations between complex systems that could result in a deeper comprehension of how complexity evolves, how it complies with some natural law, and how it relates to simplicity. Thus, the attractiveness of the approaches advanced in this research effort for modelling, design and analysis of general purposes resides in their capacity to yield complex emergent behaviours from a small set of rather simple rules, constraints and relationships expressed in quantitative or qualitative terms (Surana, Kumara, & Greaves, 2005). The major feature found in complex systems is the emergence of highly structured aggregate behaviour across time through the combination of small subsystems with no centralised control.

Among the scholars that have sought to theorize issues of complexity and governance, (Duit & Galaz, 2008), following the research of Kooiman (2003) and Pierre and Peters (2005) present interesting insights related to the ability of governance systems to cope with change and uncertainty. The model they present is a four-governance framework articulated on two key variables, which are exploration and exploitation. The most crucial issue they highlight is the difference between governing complexity and in governing complex adaptive systems. Complexity is generally defined as an implication of change, uncertainty, and limited predictability,

while complex adaptive systems have common features that result from their emergent properties. (Duit & Galaz, 2008) consider not only how change is played out between governance systems on different scales but also how different governance systems respond to complex adaptive change over time. As large parts of the world is not characterized by linear and predictable social, economical, or ecological processes, only a governance type that combines high capacities for exploration and exploitation, defined as the robust governance type in their framework, can be expected to perform well regardless of the certainty and rate of change (Duit & Galaz, 2008)

(Surana, Kumara, & Greaves, 2005) argue that supply chains should be treated as a CAS.

Governance systems continue to become more networked, collaborative, and interdependent. (Kim, Johnston, & Kang, 2014) discuss how complex adaptive systems (CAS) modeling can inform performance management research and design. As (Kim, Johnston, & Kang, 2014) point out, instead of reducing a phenomenon to a snapshot of causal variables with an error term, CAS models typically show how aggregate structures emerge from simple schemata and interactions of microstate events.

Agent Based Modelling:

Agent-based modeling (ABM) is a technique from complexity theory that has been a key instrument in gaining knowledge of CAS and general complex systems. ABM is a bottom-up approach which simulates the underlying processes believed responsible for the global pattern and allows us to evaluate what mechanism are most influential in producing that emergent pattern. The basic idea of an Agent Base Modelling is to define a system through the choices of individual actors. Each actor is defined by the behaviour it will assume in a given situation. The typical example of Agent Base Modelling is the case of sheep and wolves. The wolves eat the sheep and reproduce according to the available resources, i.e. the sheep. Consequently, when wolves are scarce, sheep reproduce and increase. As wolves eat sheep, resources decrease and the number of wolves also decreases. In this way, the general behaviour of the system is reconstructed from the one of the individual agents.

The behaviour of agents can be regulated by a multitude of different theories, such as Stwardship Theory, Agency Theory, Game theory and so on. In a project management context the difficulty lies in identifying the set of properties that defines each agent.

(Kim, Johnston, & Kang, 2014) propose ABM as computational approach to understand performance in networked governance systems. The model focuses on choosing an appropriate game theoretic dilemma (such as prisoner's dilemma, social goods games, the tragedy of the commons, the minimum-effort game, and the ultimatum game) to describe the environment observed. The game-theoretic model aims to articulate the way in which each individual agent chooses from a set of options depending on the payout, which is the result of a

combination of the agent's choice and the choices of other agents. Information from each stakeholder's relationships is used to calculate an overall decision on whether to collaborate.

(Hsu, Weng, Cui, & Rand, 2015) utilize Agent-Based Modeling (ABM) to understand the complexity of project team member selection and to examine how the functional diversity of teams and worker interdependence affect team performance in different economic conditions. They suggest that managers should protect their higher-performing workers by minimizing interdependence disruption when building teams.

System Dynamics

Systems dynamics is another approach to manage complexity builds upon tools and techniques to understand and improve system steering capabilities. It is a continuous simulation methodology based on feedback control system to model and analyse dynamic socio-economic systems. In projects, system dynamics investigates the mechanism behind circular feedback within a complex system, seeking to provide an understanding of the underlying structure of such systems. System dynamics has predominantly been applied to study transition in descriptive ways, whereas simulation and modelling has only been applied in few cases (Kliem & Scheidegger, 2020). The disadvantage of systems dynamics models is that the model structure must be determined before starting the simulation, in contrast to agent-based modelling which is a 'bottom up' approach.

(Lyneis & Ford, 2007) identify four key subjects that system dynamics addresses at project level:

- Project features: System dynamics focuses on modeling features found in actual systems. In projects these include development processes, resources, managerial mental models, and decision making.
- A rework cycle: described as the most important single feature of system dynamics project models. If the rework cycle is recognized, management can take actions to minimize its consequences.
- Project control: system dynamics focuses on modeling the controlling feedback loops through which management attempts to close gaps between project performance and targets directly applies one foundation of system dynamics to project management.
- Ripple and knock-on effects: Modeling ripple effects in projects captures and leverages the concept of policy resistance. Capturing knock-on effects in project models uses the concept of unintended side effects to explain project behavior and performance.

In *figure 2* we can see an example of a causal loop diagram from (Dawson, Elbakidze, Angelstam, & Gordon, 2017).

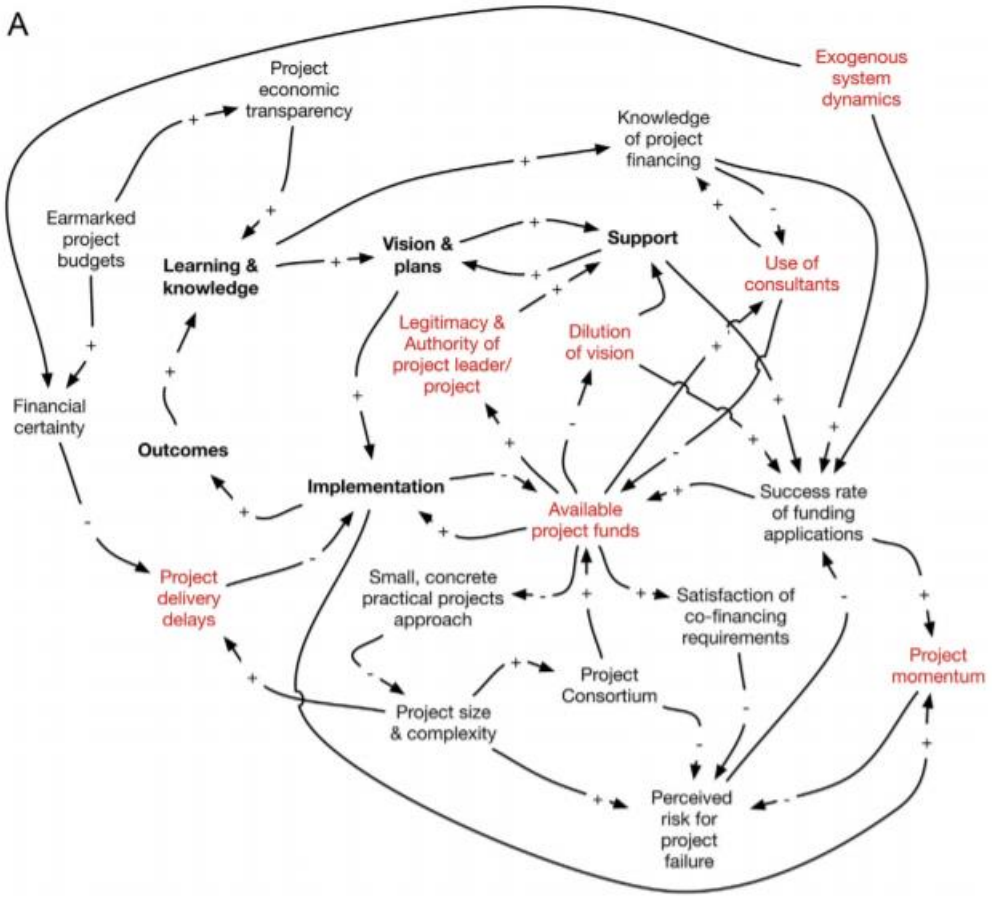


Figure 2 Causal Loop Diagram

Systems Engineering:

System Engineering is an interdisciplinary field of engineering that focuses on the successful delivery of systems in complex environments through a comprehensive set of approaches, techniques and tools. The focus of systems engineering is on the system as a whole and the maintenance of a strong interdisciplinary approach (Faulconbridge & Ryan, 2003). According to the Systems Engineering approach, the implementation of successful systems in complex contexts is carried out through the definition of customer needs and required functionalities at the beginning of the development cycle, the documentation of requirements, finally through the project design synthesis and validation of the system, considering the whole process. “System governance increases the likelihood of project success” (Locatelli, Mancini, & Romano, 2014).

A system is a complex set of many often-diverse parts subject to a common plan or serving a common purpose. In the broadest sense, a system is something that provides a solution to a complex problem. Projects can thus be considered as systems (Vidal & Marle, 2008).

Systems Engineering, taking into account all relevant factors when implementing change ensures that the big picture is designed for, avoiding solutions that are an aggregation of optimised subsystems, but are ineffective overall due to the interactions between the subsystems. According to (Locatelli, Mancini, & Romano, 2014) is based on a set of high-level governance approaches implemented in the practice with a set of techniques and tools.

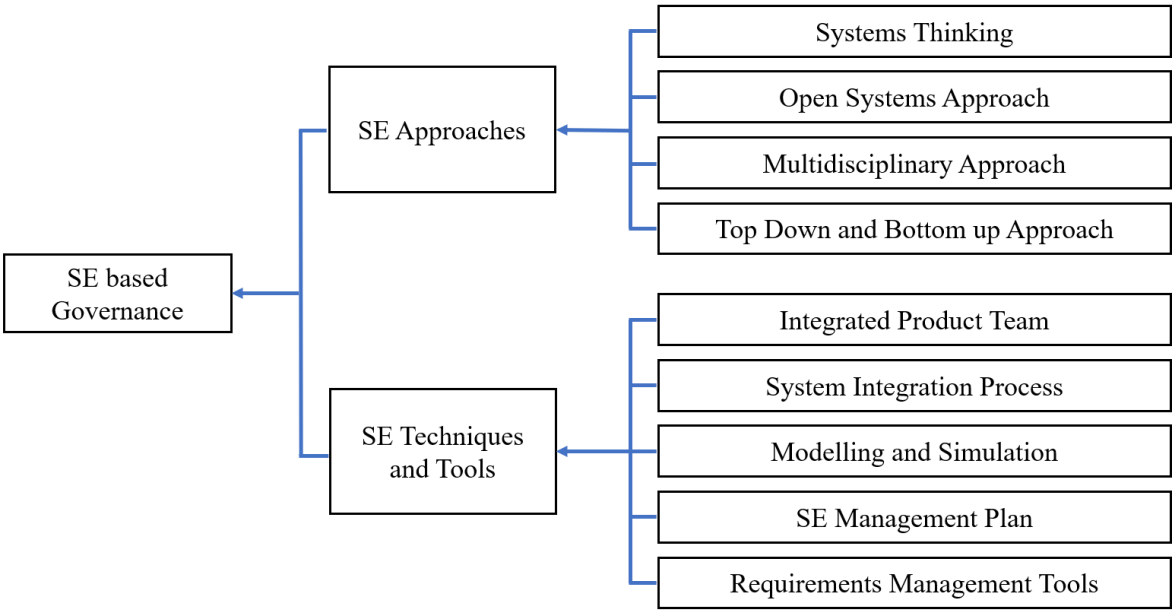


Figure 3. Source: (Locatelli, Mancini, & Romano, 2014)

Systems thinking

Systems thinking is method designed to analyse and understand how different related elements, considered as systems, influence each other within a whole (Jackson, 2003). System thinking sees a system as the result of interconnected, hierarchically organised, technical and social entities that normally produce a behaviour that results unpredictable analysing the behaviour of the isolated parts of the system. The underlying assumption is that a system, having emerging properties, is more than the sum of its parts. The main tool of system thinking is system dynamics.

According to (Kapsali, 2011) and (Emes & Griffiths, 2018), the governance based on Systems Thinking is able to:

- deal with the increasing complexity of projects;
- examine complex problems from different sectors of technology and business, highlighting their common features when combined in systems;

- link together the wide range of specialist techniques needed to solve complex problems, improving the realism of cost estimates and schedule, understanding that projects are not deterministic;
- set up new approaches in how both individuals and organisations work.

Systems thinking does not seek to replace traditional top-down thinking, but to complement it. Systems Thinking requires problem solving to be carried out on a more multidisciplinary basis in order to involve System Engineering governance stakeholders with a broad set of skills and competences. Systems Thinking successfully contributes to the governance of innovativeness, complexity and uncertainty by incorporating flexibility in managerial activities.

There are two main forms of Systems Thinking: hard and soft.

Hard Systems Thinking, the first form of SE to emerge, is designed to tackle well-defined projects with reliable data, defined objectives and systems that can be optimised using classical engineering methodologies. An example of such project is the optimisation of the production of a chemical plant already in use.

Soft Systems Thinking approach is ideal to cope with problems involving incomplete data, unclear goals, human beings and cultural considerations. Change is inevitable in large projects and it is typical that objectives evolve during the life span of mega-projects. A systemic methodology could identify what changes are feasible and desirable from the problem context. Soft Systems Thinking is founded on learning systems centred on communication, cross-subjective complexity and interpretations. It refuses the idea of a single design solution and treats systems as problematic since they involve many different views of the world, with different perspectives, experiences and goals that change over time. Soft Systems Thinking is a learning system that seeks to improve complex environments. By exploiting both types of ST it looks into Complex Systems Science, such as chaos, complexity, complex adaptive systems, non-linear statics and dynamics, social science, power laws, ecology and others. Its purpose is to enhance the understanding of complex systems to improve the implementation of SE in complex environments.

(Sheffield, Sankaran, & Tim Haslett, 2012) suggests a framework that analyses a project based on the number of iterations and the number of its components, correlating a methodology to each project context. The Agile method can be used to mitigate project uncertainty in dynamic environments, but as projects become more complex, this methodology may result unable to address the problem from a broader perspective. Complex projects and complicated projects are both characterised by a high number of interactions and a high number of components, with the difference that complex projects add a high level of uncertainty in the organisational domain, including a large number of unknown processes. Thus, complicated projects require a high level of specialist knowledge to complete, while complex projects are those who benefit most from Systems Thinking methodology.

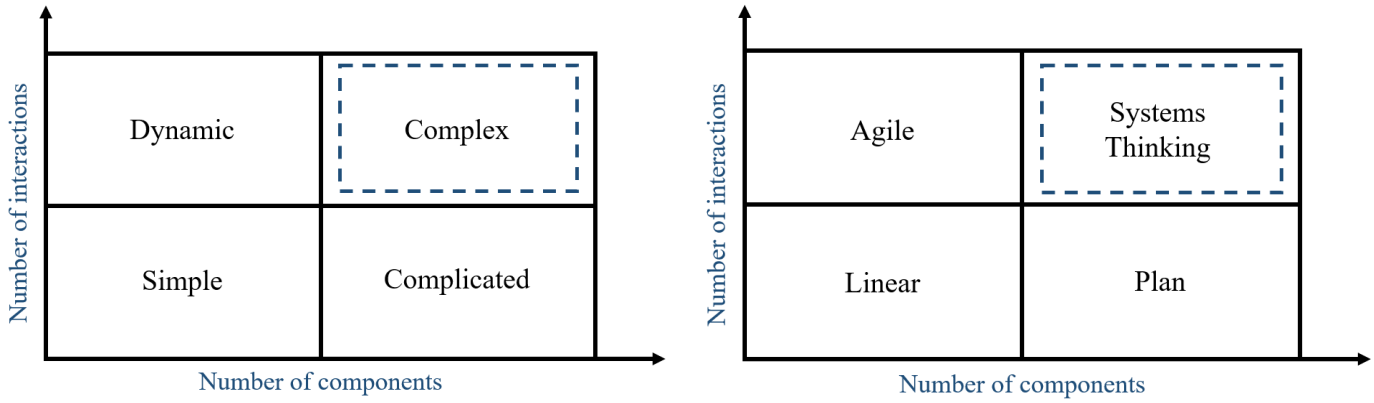


Figure 4 (Sheffield, Sankaran, & Tim Haslett, 2012)

According to (Kim D. H., 2000) there are ten general types of systems thinking tools:

Brainstorming Tools	Dynamic Thinking Tools	Structural Thinking Tools	Computer-based Tools
Double-Q Diagram	Behaviour Over Time Diagram	Graphic function diagram	Computer Model
	Causal Loop Diagram	Structure-behaviour Pair	Management Flight Simulator
	System Archetype	Policy Stucture Diagram	Learning Laboratory

Figure 5

(Emes & Griffiths, 2018) conducted a series of interviews across defence, aerospace, rail, public services, construction, automotive, transport, government, information technology and consumer electronics industries, finding that causal loop diagrams of system dynamics approach are the most recognised form of systems thinking amongst the types listed above.

Considerations:

This chapter addresses the ways associated with managing the interaction of actors operating in dynamic and complex networks and at various scales of governance. One can conclude from the literature that project governance is contingent on its application and on its environment. This is certainly true and in fact is the premise of contingency theory.

Methodologies for complex project management are intended to support project governance in a unique tool for monitoring and analysing of a project by studying its characteristics from different points of view. They focus primarily on extrapolating the macroscopic behaviour of a complex system from a set of simple underlying rules. Agent-based modelling deals with the behaviour of individuals, system dynamics looks for causal relationships within the system. These methodologies are increasingly being used in the field of project management as they are extraordinarily powerful tools for simulation and consequently prediction, enabling the extrapolation of managerial implications.

However, most of the studies currently available in the project governance literature seems to focus on one field in particular in the management of complex systems, network science. Networks represent a well-established tool for giving a highly comprehensible graphical representation of complex phenomena. Network approaches focus more on the study of relationships than on the characteristics of individuals. Consequently, they are not intended as an alternative to the approaches seen, rather as a complementary system whose primary function is to visualise the behaviour of the project/organisation.

Network science will be indeed dealt with in detail in chapter three.

Chapter 2

Research Problem:

There has been a constant stream of contributions applying governance methodologies in project management. Project governance is a broad field and can materialize under a broad range of topics and in different forms and implementations such as frameworks and theories, but it remains difficul to find pragmatic tools to bridge the gap between theory and practice. Even though existing studies have revealed a wide range of relevant findings, it remains difficult to compare and evaluate different studies and to derive managerial implications, which must then be embodied in the practical instrument we are looking for. These difficulties are related to:

- use of vague or inconsistent definitions and a variety of meanings of governance factors and terms related to governance;
- identification and analysis of a vast multitude of influencing factors;
- lack of a systematic overview of the field

As the body of literature on governance theory in a project management context is large and multifaceted, a bibliometric study was selected as a research approach to identify relevant contributions and give an overview of project governance methods. Following an explorative pathway, the aim is to outline which methods, frameworks and tools have already been applied to project governance.

In this research, it was decided to focus in a first step on a specific dimension of the concept, using co-authorship as a general indicator, in order to detect what is generally understood as formal collaboration. In a second step, it was considered appropriate to also analyse the informal aspects of collaboration, as it is assumed that exchanges between scholars are much broader and involve different actors, who have different interests, and that often these exchanges do not lead to joint work, so publishing together returns only a part of the knowledge generation scenario.

The data were analysed with statistical and bibliometric methods. The greatest limitation of the research is the necessity to rely on the quality of the data available in the databases. In some cases, it has been necessary to manually cross-check and correct the data.

The use of this methodology is aimed at finding the most relevant documents in terms of citations, but also at defining the most interesting research clusters in terms of quantitative methods of project governance. The themes thus identified will then be analysed in greater depth at the end of the chapter.

This research work attempts to provide a better understanding of the field of project governance, allowing us to identify:

- Which contributions received the highest number of citations during the analysed period and consequently can be considered the most influential in the consolidation and/or future evolution of the field;
- What is the knowledge base or intellectual structure of recent research in the field of project governance using co-citation analysis and other techniques.

Social Network Analysis as a research method

Social Network Analysis is made up of a set of methods and techniques, which finds application in various fields. One of them is bibliometrics, which is an effective way to describe research development in various science domains. It provides knowledge in a certain research field by capturing and analysing information such as the year of publication, author, country and institution, and keywords in published academic articles.

The field of scientific research can be represented in the form of a network, since each author, when citing or collaborating with another author, establishes a link which can be represented by means of a graphical visualisation. Social Network Analysis has been used to identify and study such collaborations. In recent years, SNA has been increasingly used for bibliometric data mining and analysis, exploring the interrelationships between keywords, countries and authors.

Data and Methodology

Bibliometric analysis is the study of the quantitative aspects of the process of science as a communication system and is used to reduce the influence of researchers' subjective opinions on research hotspots and enhance the objectivity and reliability of results (Zhao Zhai & Amos Darko, 2020). Using co-citation analysis, bibliometric can develop knowledge mapping of scientific fields. The co-citation analysis method is aimed at determining the subject similarity between articles, based on the logic that when articles are published within a particular research stream, they are assumed to address similar topics.

To collect data, this study used the VOSviewer 6.15 mapping algorithm (Van Eck & Waltman, 2010), which is a scientometric research and modelling tool. To retain the authors' meaning, the authors' keywords were used, and present and index keywords were supplemented. Keyword lists were also edited to remove common terms that did not assist in the identification of topics. In particular, keywords such as 'project management',

‘project governance’, ‘governance approach’, ‘governance’, were removed to reduce noise in topic categorization. Other words not relevant such as the name of the states and the type of paper were removed.

VOSviewer was chosen as a science mapping techniques tool as is developed to explore emerging trends and the most relevant innovations in different scientific areas. VOSviewer supports author cocitation analysis, document cocitation analysis, and coword analysis by modeling and visualizing networks and maps. In the visualization knowledge maps, there are nodes and links representing elements (i.e., authors, institutions, and countries) and relationships of collaboration or cocitations. Authors, institutions, and countries were selected as node types to determine the major facets of project governance research. In each case, the links in the map showed scientific collaborations. To reveal the research patterns and trends in the field, keyword co-occurrence and cluster analyses were performed, with the nodes being keywords and references and lines that connected nodes being co-citation links. Based on keyword co-occurrence analysis, some general prominent research groupings can be identified through the clustering function.

The steps of the review began with the identification of the primary studies through database searching. Scopus has been identified as the data source, as it presents a database of bibliographic records that are necessary for VOSviewer software.

Two analyses were carried out. A first analysis involves all studies currently available on Scopus, without any filtering of any kind. This included articles, conference papers, books, reviews and so on. In the same way, the research fields and the sources are as varied as possible. This approach has the only purpose of having the broadest possible view of this research field, i.e. project governance in its quantitative forms. The second reason is that this analysis is useful for comparison with a second analysis, this time of a narrow range of selected studies. For this type of analysis, we chose to analyse only papers from journals, which represent the highest degree of reliability in the world of scientific research. In this case, reviews were excluded following a rigorous and unbiased approach, as they report information already contained within the papers under analysis. The data from the second analysis certainly deserve more attention as they represent the state of the art in this field of research.

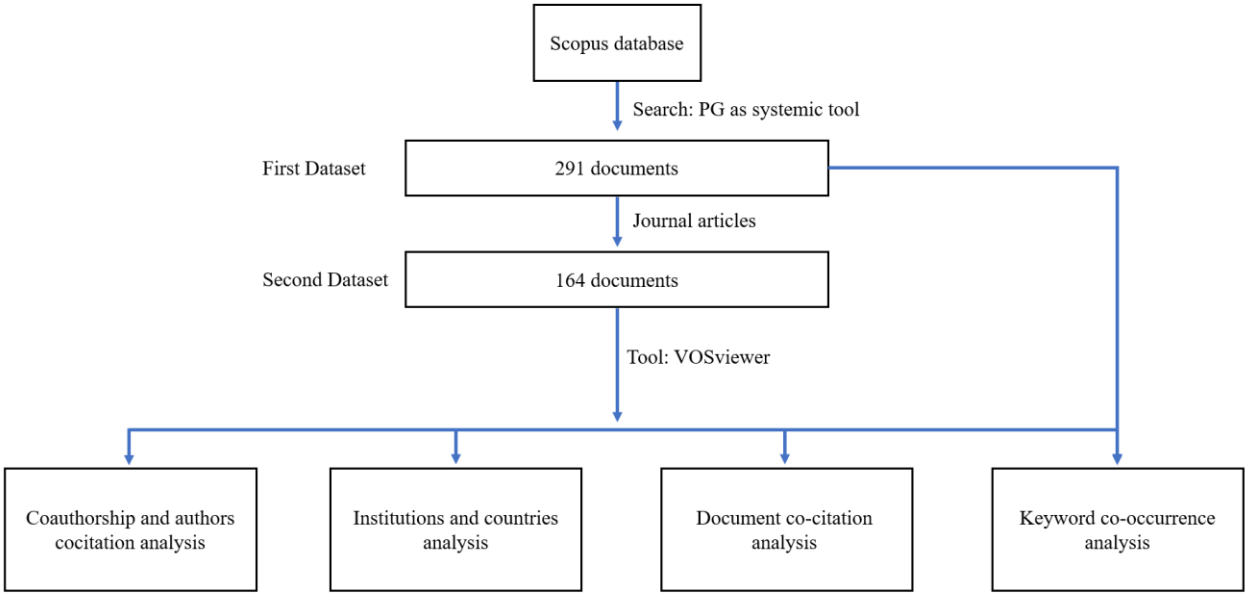


Figure 6. Methodology

The aim of this research is to find quantitative approaches to link governance and project success. First of all, we selected only those studies with the terms "project governance" in Title/Abstract/Keywords. 453 documents were found, distributed over a time span from 1979 to now, with a real increase in publications only since 2000. It can therefore be seen that Governance applied to projects is a relatively recent field of study, whose interest is becoming increasingly high.

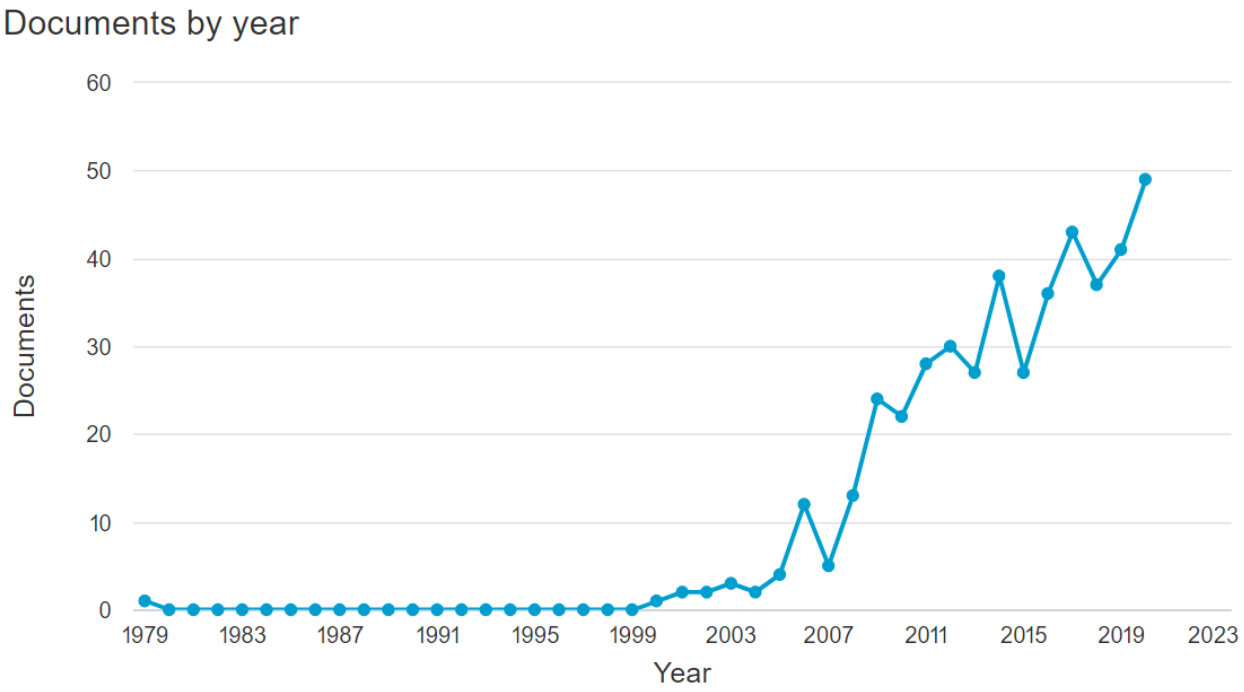


Figure 7 Project governance documents (Scopus)

As a second step for the selection of data, only the documents with at least one of the following words within the Title/Abstract/Keyword fields were selected:

- tool;
- quantitative;
- approach;
- model;
- method;
- predictive;
- holistic

The choice of such keywords is the result of an iterative process carried out in order to exclude anything that was not purely quantitative in terms of Governance. Among the 301 remaining documents, only the Documents in English have been selected thus reaching 291 documents, and this constitutes the first dataset analysed. As mentioned before, in order to have as broad a sample as possible of quantitative approaches to governance with an overall view of the field, all subject areas have been preserved.

Scopus query first dataset:

TITLE-ABS-KEY ("project
governance" AND (tool OR predictive OR quantitative OR approach OR method* OR model* OR holistic)) AND (LIMIT-TO (LANGUAGE , "English"))

As regards the second dataset analysed as mentioned above, only papers were selected, thus excluding conference papers, books, reviews and so on. A journal is a periodical publication focusing on a certain subject. It contains a specified number of peer-reviewed articles that are generally regarded as reliable and are ideal sources to cite. A conference, instead, is a place where scholars, researchers, professors and academics meet to discuss research and developments in a given domain.

In order to have as wide a sample of but at the same time relevant to the subject matter, the following fields have been chosen: Business, Management and Accounting; Engineering; Computer Science; Social Sciences; Decision Sciences; Economics, Econometrics and Finance; and Energy. The other subject areas, having a very small sample of documents, may propose models that are too specific, contingent on a single context and therefore irrelevant for a research of this kind.

Papers resulting from this selection are 174, distributed over a time span from 2001 to 2021. The number of studies increased gradually and fluctuated since 2007. It could be observed that before 2016, the number of publications per year in this field was relatively small. In 2016, the numbers increased sharply from 15 to 25 in 2017. It might be a significant year from when new approaches to governance got increasing attention.

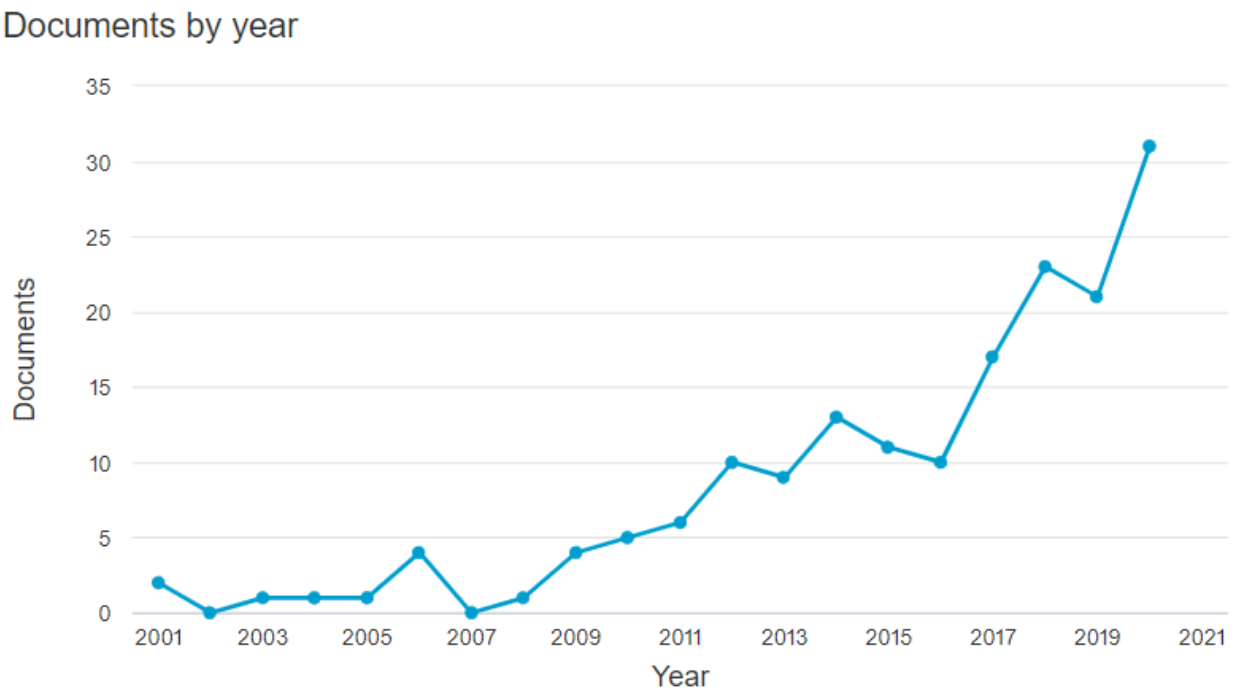


Figure 8

The main journals by number of articles are:

- International Journal Of Project Management (41 papers)
- International Journal Of Managing Projects In Business (24 papers)
- Construction Management And Economics (9 papers)
- Journal Of Management In Engineering (7 papers)
- Sustainability Switzerland (6 papers)

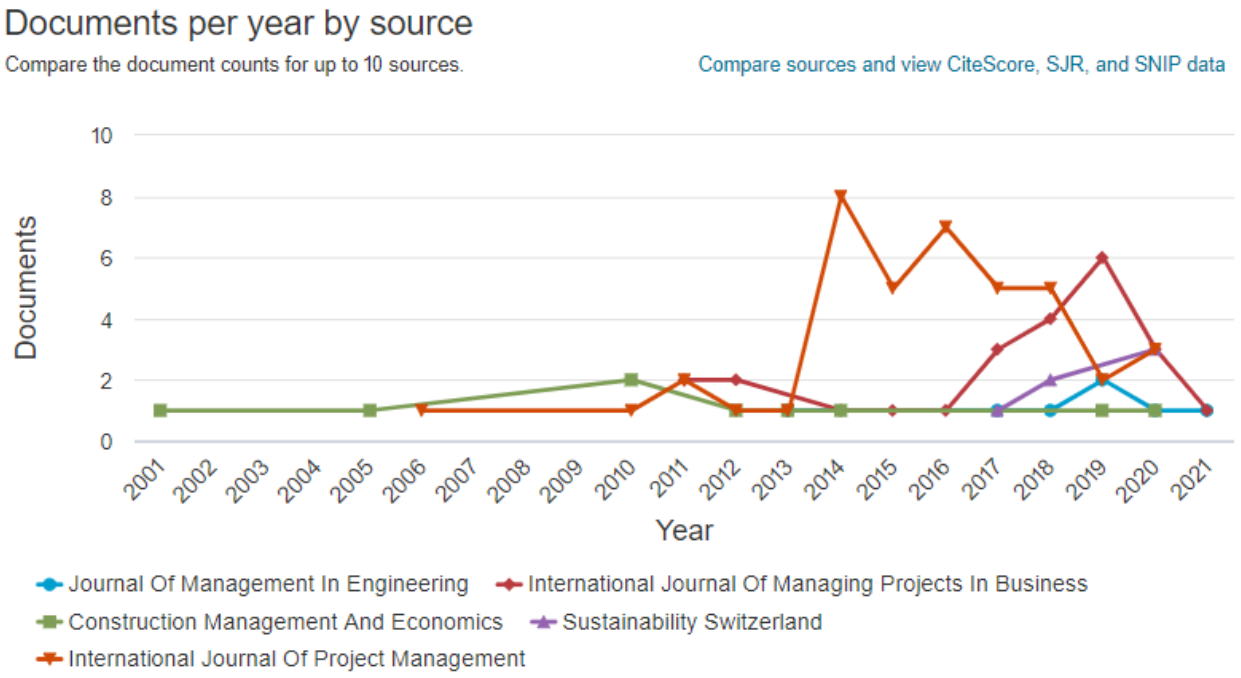


Figure 9 Journals

Scopus query second dataset:

TITLE-ABS-KEY ("project governance" AND (tool OR predictive OR quantitative OR approach OR method* OR model* OR holistic)) AND (LIMIT-TO (LANGUAGE , "English")) AND (LIMIT-TO (DOCTYPE , "ar")) AND (LIMIT-TO (SRCTYPE , "j")) AND (LIMIT-TO (SUBJAREA , "BUSI") OR LIMIT-TO (SUBJAREA , "ENGI") OR LIMIT-TO (SUBJAREA , "SOCI") OR LIMIT-TO (SUBJAREA , "ENVI") OR LIMIT-TO (SUBJAREA , "DECI") OR LIMIT-TO (SUBJAREA , "COMP") OR LIMIT-TO (SUBJAREA , "ENER") OR LIMIT-TO (SUBJAREA , "ECON"))

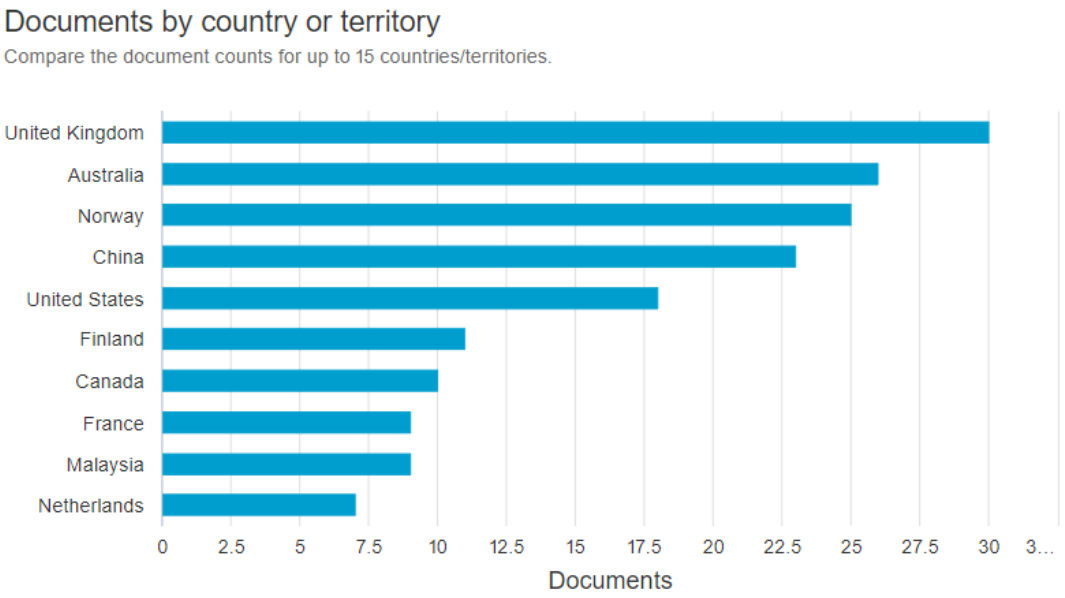


Figure 10

All the analysis presented utilize the full counting method. Full counting means that a co-authored publication is counted with a full weight of one for each co-author, which implies that the overall weight of a publication is equal to the number of authors of the publication. Fractional counting means that a co-authored publication is assigned fractionally to each of the coauthors, with the overall weight of the publication being equal to one. Hence, in the case of fractional counting, each publication has the same overall weight. In the context of the construction of bibliometric networks, the concept of a co-author is replaced by the concept of a link. When full counting is used to construct a bibliometric network, each link resulting from a pubblication has a full weight of one, which means that the overall weight of an action is equal to the number of links resulting from the action. (Perianes-Rodriguez, Waltman, & Eck, 2016) present an empirical comparison of the full and fractional counting methods for constructing bibliometric networks, concluding that in analyses based on small data sets, as the one of this research, it seems unlikely that results obtained using full and fractional counting will be very different, the only difference between the two networks is in the strength of the links.

As normalization method was used the association strenght. The normalization is used to drop down list to determine how the strength of the links between items is normalized.

In these kind of network visualizations, items are represented by their label and by default also by a circle. The size of the label and the circle of an item is determined by the weight of the item. The higher the weight of an item, the larger the label and the circle of the item.

Authors Analysis

Co-authorship

Co-authorship network shows with whom each author has collaborated in the production of journal articles. This analysis can be useful in the identification of thematic clusters, whose composition can be clearly defined in this way. In the final dataset, there were 361 authors who contributed to the documents between 2001 and 2020, using 595 keywords to categorize their work.

In *figure 3* the most frequent authors are shown. Among the representative authors, Ralf Müller (BI Norwegian Business School), Jonny Klakegg ¨ (Norwegian University of Science and Technology) and Ashwin Mahalingam (Indian Institute of Technology Madras) occupied the top three positions.

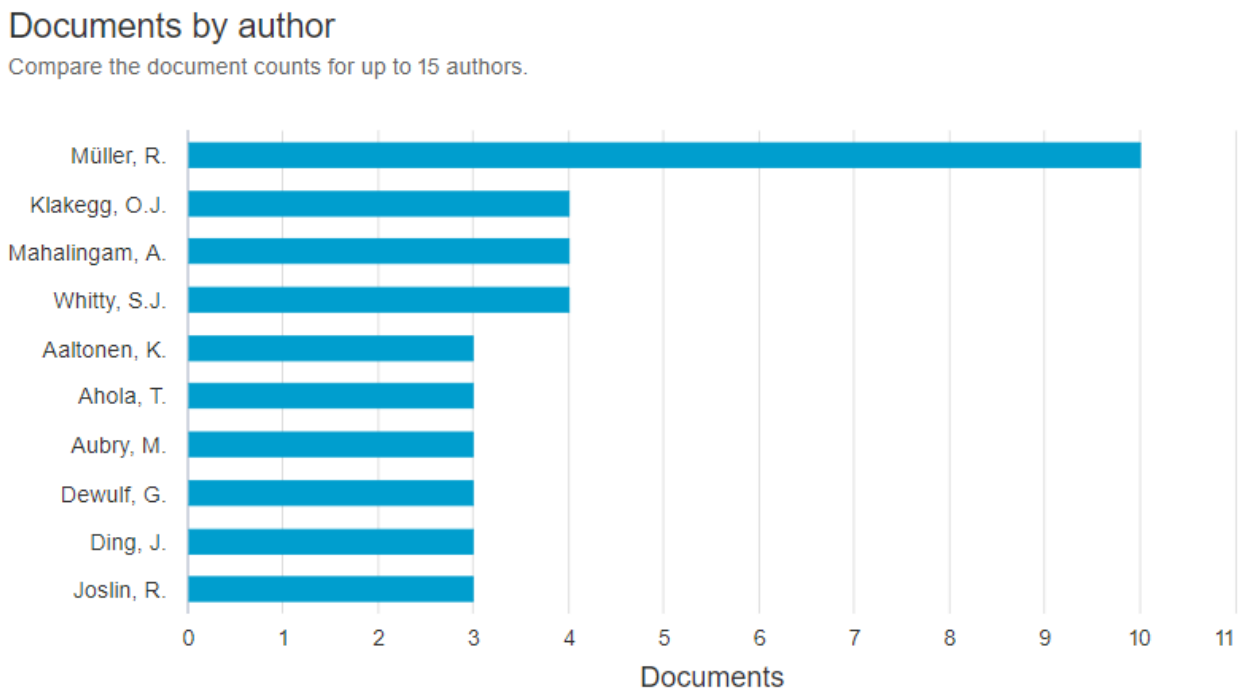


Figure 11

By applying coauthorship analysis, a group of productive authors who have contributed a large number of publications can be identified. Figure below shows a coauthorship network, in which each node represents an author, node size represents the number of publications, and links between nodes denote collaborations among the authors. The network shows a high degree of fragmentation (i.e., a comparatively separated field of authors) because it consists of 107 clusters, 503 links and 361 items. There are several closed-loop circuits, among which 12 main clusters can be identified. The clusters of authors are shown in detail below.

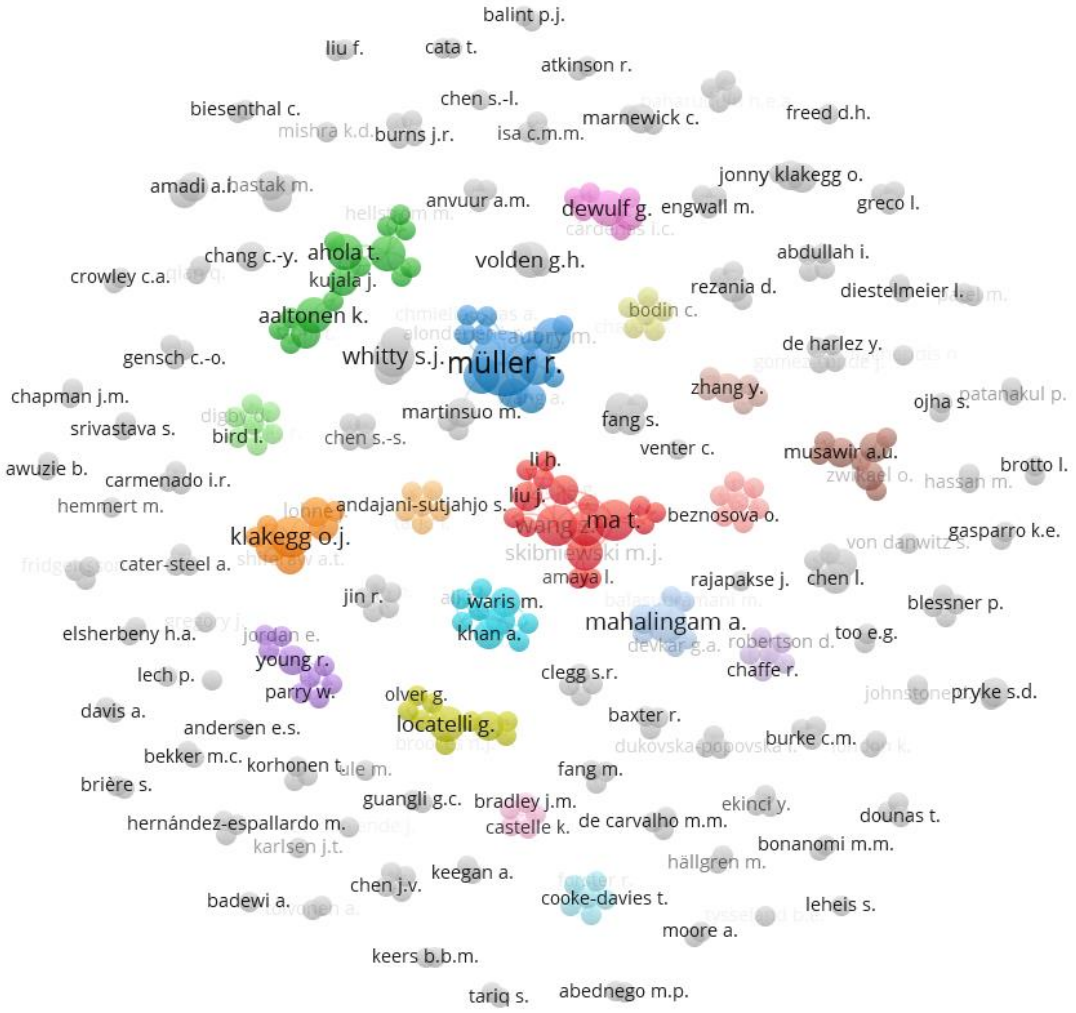


Figure 12 Coauthorship Network

As can reasonably be expected, the first cluster consists of Ralf Müller citations, author already covered in the first chapter. Closest connections exist between Ralf Müller, Jingting Shao, Robert Joslin, Sofia Pemsel, Monique Aubry, Miia Martisuo and a subcluster composed by Margarita Pilkienė, Raimonda Alonderiené, Saulius Šimkonis and Alfredas Chmieliauskas. Most contributed topics of Ralf Müller are Governance, Project Success, Project-based Organizations, Office Management, Project Control, with a Topic Field-Weighted Citation Impac reported by Scopus as 1.20. This index shows how well the documents in the topic are cited compared to similar documents. A value greater than 1.00 means the documents are more cited than expected.

This central component is depicted in *figure 13*.

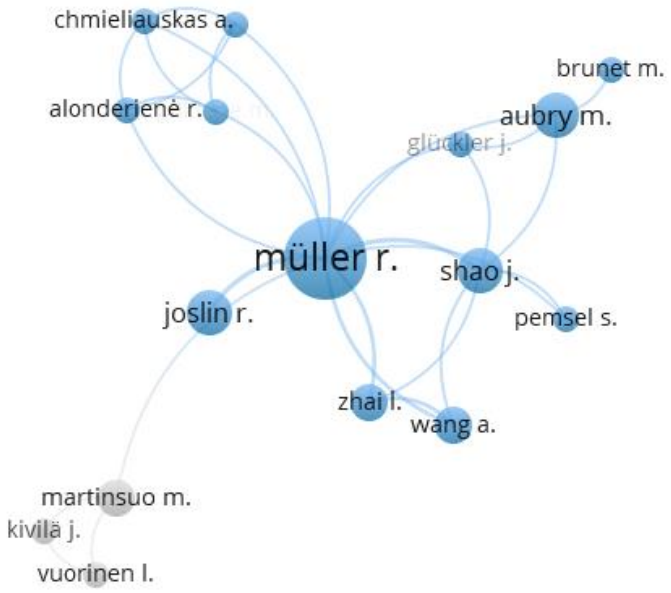


Figure 13

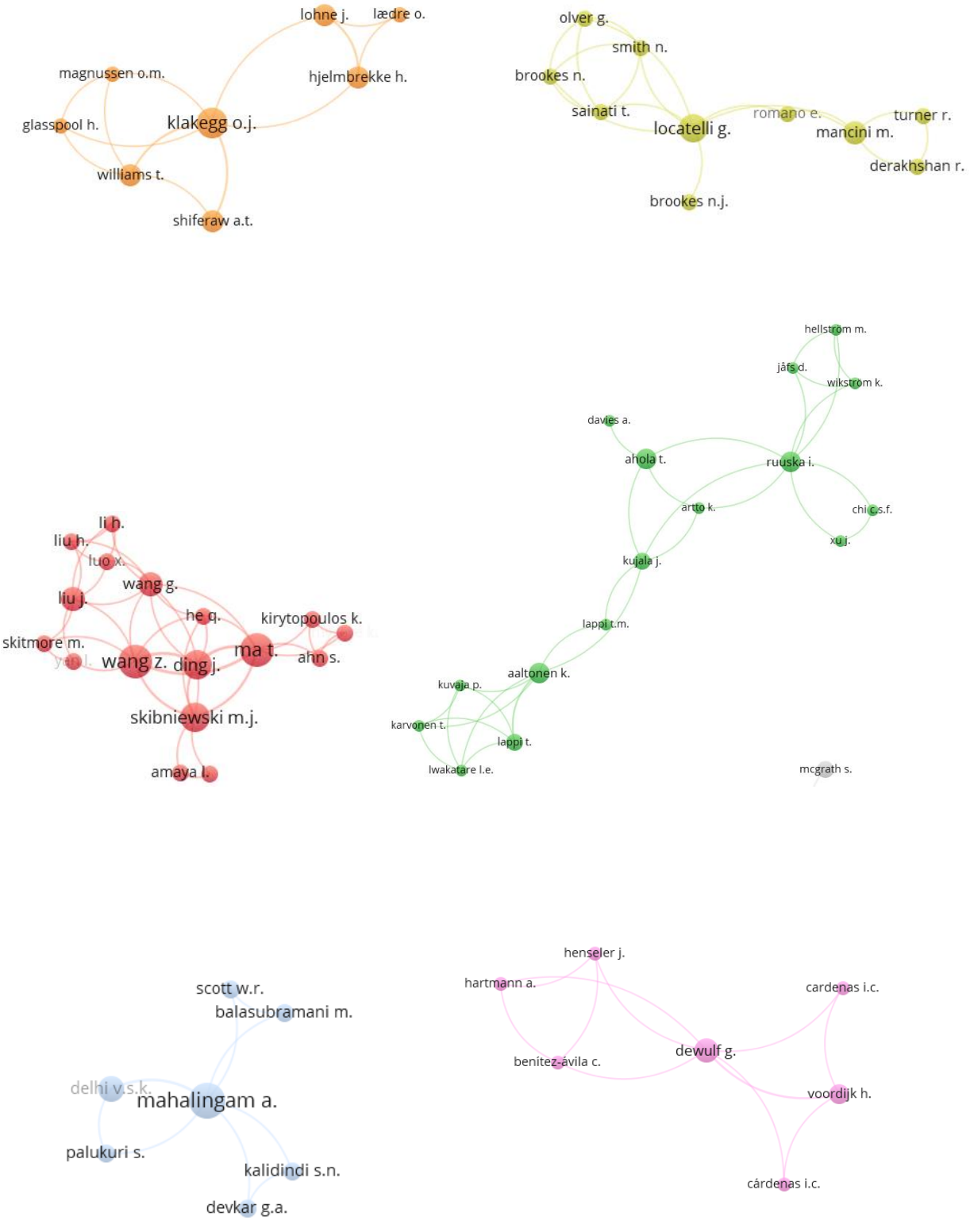
Similarly, strong cooperative relationship can be found between Jonny Klakegg, Terry Williams, Asmamaw Tadege Shiferaw, Jardar Lohne and Hallgrim Hjelmbrekke. Most contributed topics of Jonny Klakegg are Project Success, Project-based Organizations, Office Management, with a Topic Field-Weighted Citation Impac reported by Scopus as 1.14.

In addition, research communities can be identified, in which many authors worked with one highly productive author. For example, Giorgio Locatelli is the central author of a research community, consisting of Erica Romano, Mauro Mancini and Naomi Brookes, which treats the system engineering approach discussed in chapter one. Turner, R., Mancini and Derakhshan, R collaborate in a review regarding project governance and stakeholders.

Other research communities can be identified, in which many authors worked with one highly productive author.

Klakegg, O.J., Williams, T., Magnussen, O.M. and Glasspool adress project governance from the perspective of public projects in “Governance frameworks for public project development and estimation” (2008).

Wu, A., Wang, Z. and Chen, S. collaborate in “Impact of specific investments, governance mechanisms and behaviors on the performance of cooperative innovation projects.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lædre o.
magnussen o.m.
hjelmbrekke h.
glasspool h.
klakegg o.j.
williams t.
shiferaw a.t.
olver g.
smith n.
brookes n.
sainati t.
romano e.
turner r.
locatelli g.
mancini m.
derakhshan r.
brookes n.j.
hellström m.
jåfs d.
wikström k.
davies a.
ahola t.
ruuska i.
artto k.
chi c.s.f.
xu j.
kujala j.
lappi t.m.
aaltonen k.
kuvaja p.
karvonen t.
lappi t.
iwakatare l.e.
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luo x.
wang g.
liu j.
he q.
kirytopoulos k.
skitmore m.
wang z.
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ma t.
ahn s.
skibniewski m.j.
amaya l.
henseler j.
hartmann a.
cardenas i.c.
benítez-ávila c.
dewulf g.
voordijk h.
cárdenas i.c.
scott w.r.
balasubramani m.
delhi v.s.k.
mahalingam a.
palukuri s.
kalidindi s.n.
devkar g.a.

Figure 14

Countries Co-Authorship and Citation Analysis

The idea behind constructing this network is to understand which authors collaborate with each other by geographical area. The main countries in the Co-citation network are the United Kingdom, United States, China, Australia and Norway. The distance between two countries in the visualization approximately indicates the relatedness of the country in terms of co-citation links. In general, the closer two countries are located to each other, the stronger their relatedness. The strongest co-citation links between countries are also represented by lines.

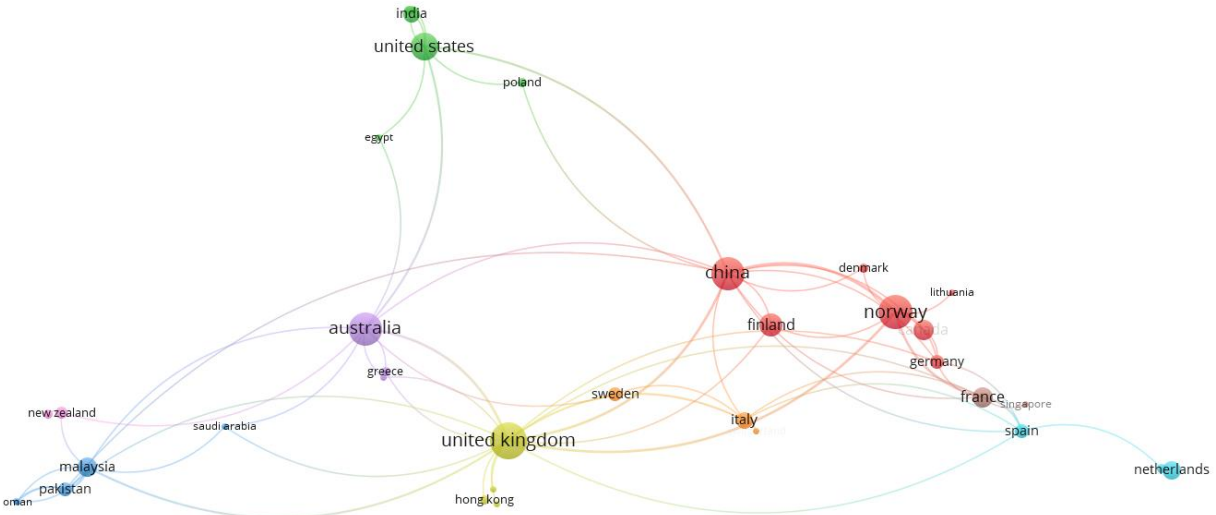

Figure 15 Countries Co-Authorship Network

In addition, the network of citations per country is presented. In this case, the size of a node is given by the number of citations received and not by collaborations.

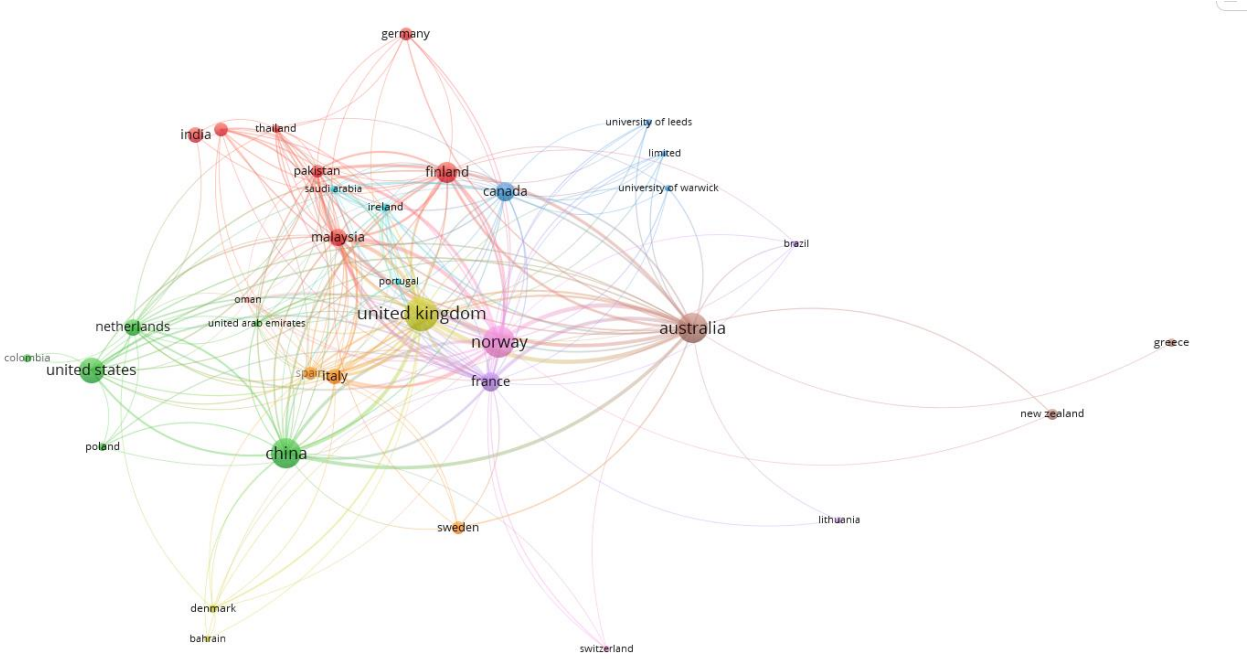

Figure 16 Countries Citation Network

Co-Citation analysis

Co-citation is defined as the frequency with which two documents are cited together by other documents (Small, 1973).The assumption of a co-citation analysis is that between two or more documents which are co-cited, namely, cited jointly in a third, subsequently published work, there would be a certain thematic similarity as well as a certain intellectual connection within the field analyzed; whereas that the higher the co-citation frequency, the greater the affinity existing between them will be it being possible to regard them as belonging to the same 'research front'. The intensity of this relationship will be determined by the number of citing documents or source documents which contain the same pair of documents amongst their references (Francisco, Enrique, Bartolomé, & Mercedes, 2019).

Interestingly, comparing the most productive authors with the most influential ones does not always reveal a significant influence from the former in the field of project governance research. Ralf Müller and J.R. Turner are the two most co-cited authors in this case, which are, moreover, closely linked in terms of correlation.

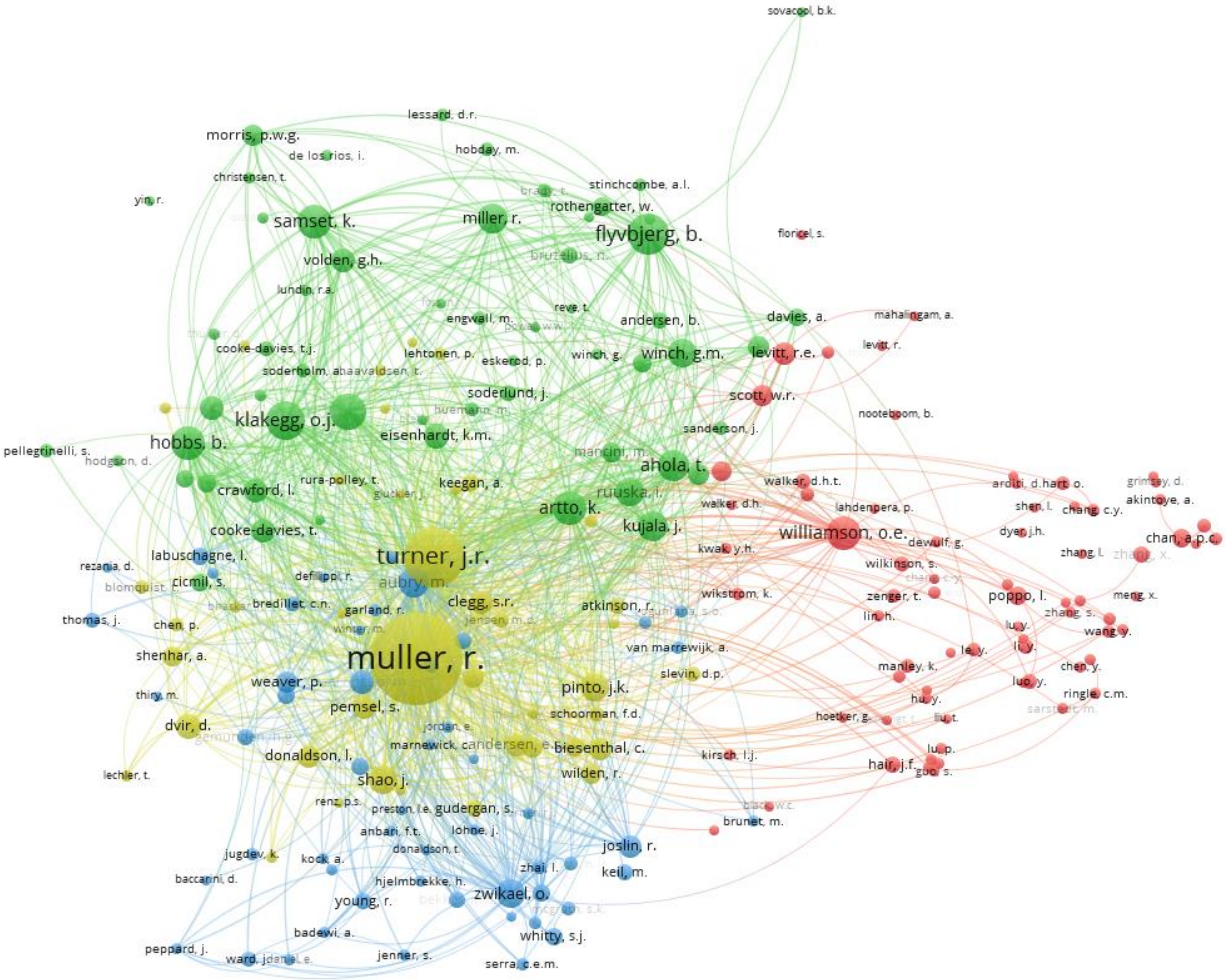

Figure 17 Co-Citation Network

Document Citation Network

In the citation network each node represents a particular journal article. The larger the node, the more it has been cited. The main articles, which we can consider as the pillars of this branch of project governance, are:

- Mechanisms of governance in the project-based organization: Roles of the broker and steward (J.Rodney Turner; Anne Keegan; 2001)
- Good project governance for proper risk allocation in public–private partnerships in Indonesia (Martinus P.Abednego; Stephen O.Ogunlana; 2006)
- The management of project management: A conceptual framework for project governance (G.Too; Patrick Weaver; 2014)
- Governing the project process: a conceptual framework (Graham M. Winch; 2010)
- Towards a social network theory of project governance (Stephen D. Pryke; 2005)
- Relationships between a project management methodology and project success in different project governance contexts (Robert Joslin; Ralf Müller; 2015)
- Multi-level project governance: Trends and opportunities (Christopher Biesenthal; Ralf Wilden; 2012)
- Benefits Realisation Management and its influence on project success and on the execution of business strategies (Eduardo Martins Serra; Martin Kunc; 2015)

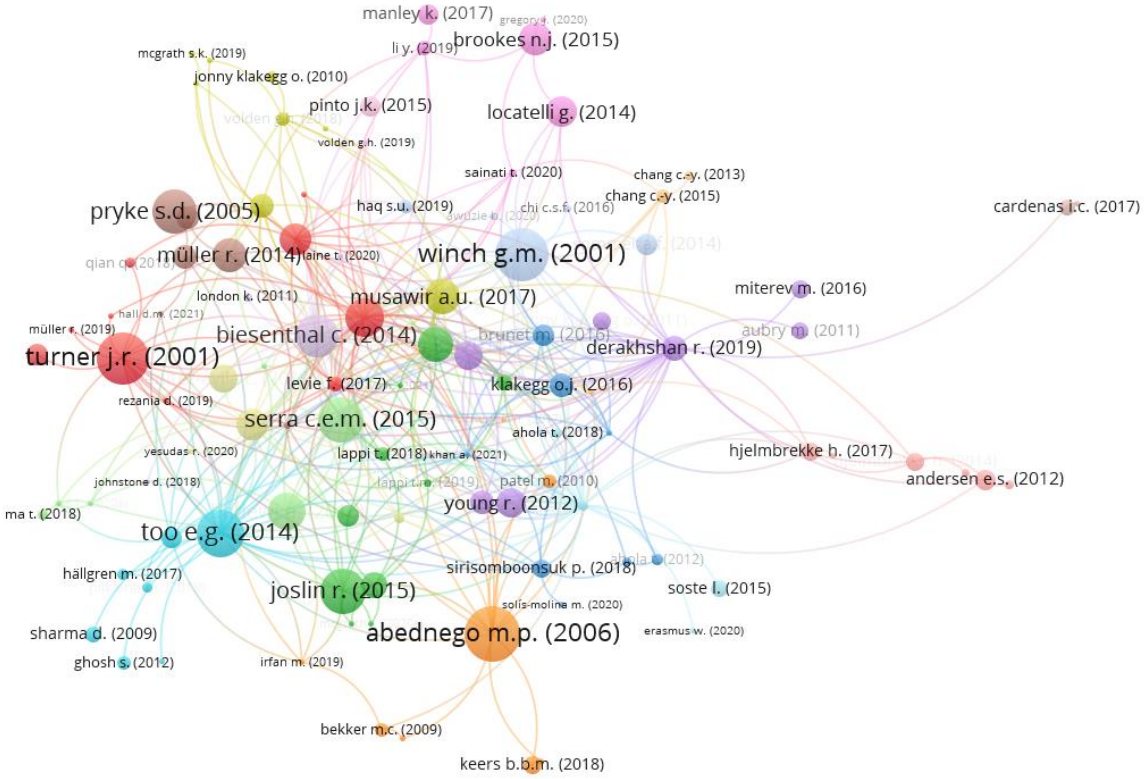

Figure 18 Document Citation Network

Institutions Citation Network

To detect the most significant cited journals that together constitute the knowledge domain of project governance research, a journal citation network is presented. Of the 71 items, the largest set of connected items consists of 35 items, presented in the figure. The graph indicates the most significant cited journals by the 164 articles with 35 nodes and 59 links.

According to citation frequency, the International Journal of Project Management is the most influential journal, followed by the International journal of Managing Projects in Business. Other relevant journal is Journal of Construction Engineering and Management.

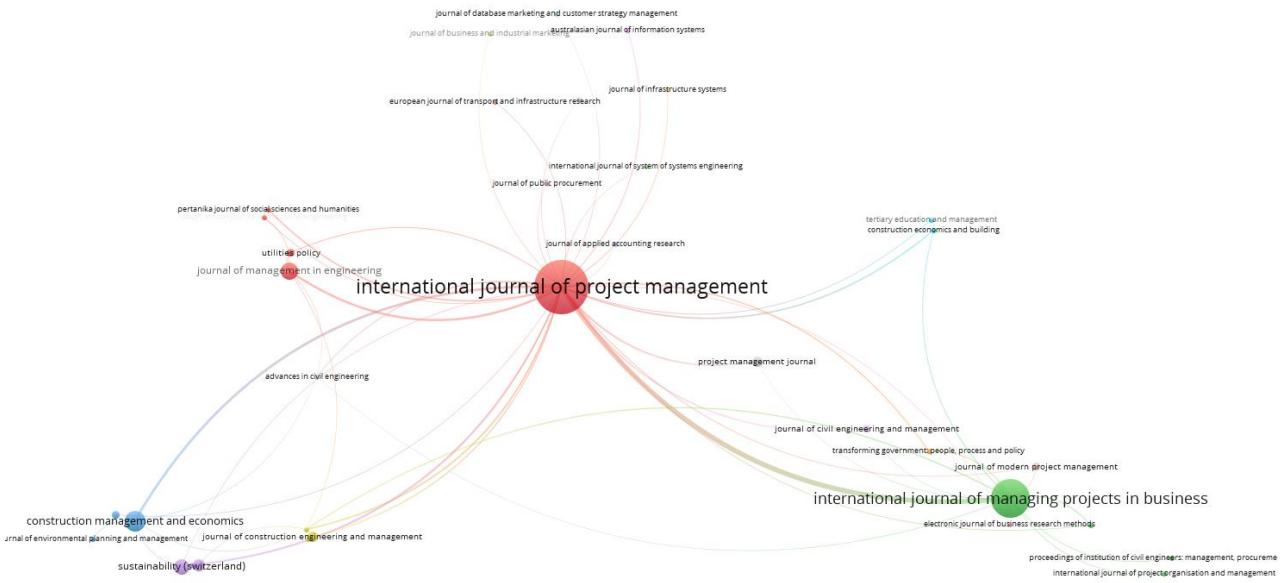

Figure 19 Institutions Citation Network

Keyword Analysis

In this analysis a comparison has been made between the first dataset, inclusive of all document types and subject fields, and the dataset of journal articles only. The aim is to establish a comparison between academic research in newspapers, which is oriented towards very specific issues, and a broader context where governance is applied across different sectors. A practical example is the fact that project governance in journal articles is highly correlated with the construction sector, while it is interesting to look for the use of quantitative project governance approaches also within sectors such as medicine, agriculture, and so on.

The keyword co-occurrence network aims at identifying topical clusters. The minimum number of occurrences of a keyword was set to 2.

Regarding the first dataset of the 2035 keywords, 419 meet the threshold and 15 clusters were identified. The total links of this configuration are 4746, with a total link strenght equal to 5750.

Regarding the second dataset of the 1178 keywords, 215 meet the threshold and 12 clusters were identified. The total links of this configuration are 1868, with a total link strenght equal to 2158.

In both datasets for the identification of main areas of interest, clusters were calculated from network data eliminating the following keywords:

“project governance”, “project management”, “governance”, “investments”.

The following focal points were identified:

- **Processes**: risk management; contracting; decision making; communication; project evaluation; relationship management; project assesment.
- **Project Types**: complex projects, megaprojects, construction projects; public private partnerships, IT projects.
- **Social Factors**: culture; leadership; relationships; teams; human management; policy
- **Miscellaneous**: contingency factors; evolutionary management; management science in project management context; project uncertainty; top management; contractual governance
- **Tools and Methodologies**: social network analysis, factor analysis, numerical model, systems engineering, systems dynamics
- **Governance theories**: contingency theory; agency theory; stewardship theory; game theory

In both datasets the results of the analysis of the documents, show that 'decision making', 'construction industry' and are the most central and dominant themes in this research literature.

Decision making" as the top keyword after "project management", "project governance" and "governance" is no surprise, as project governance is a level of implementation of the decision-making process.

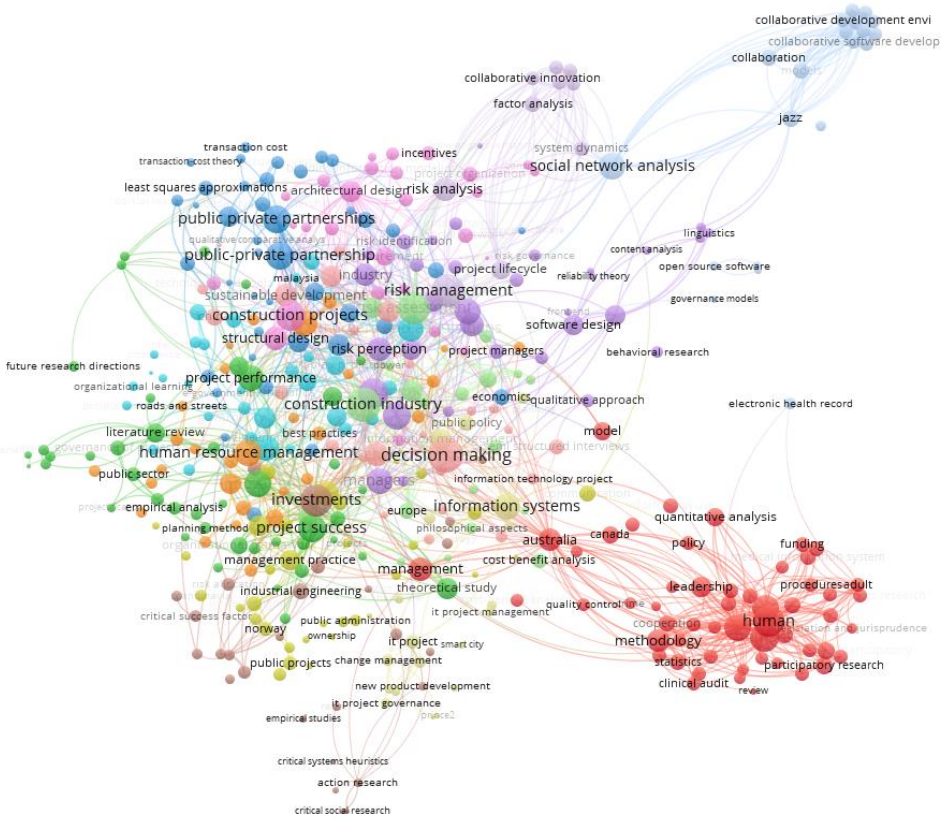

Figure 20 Co-occurerence Keywords Network Dataset 1

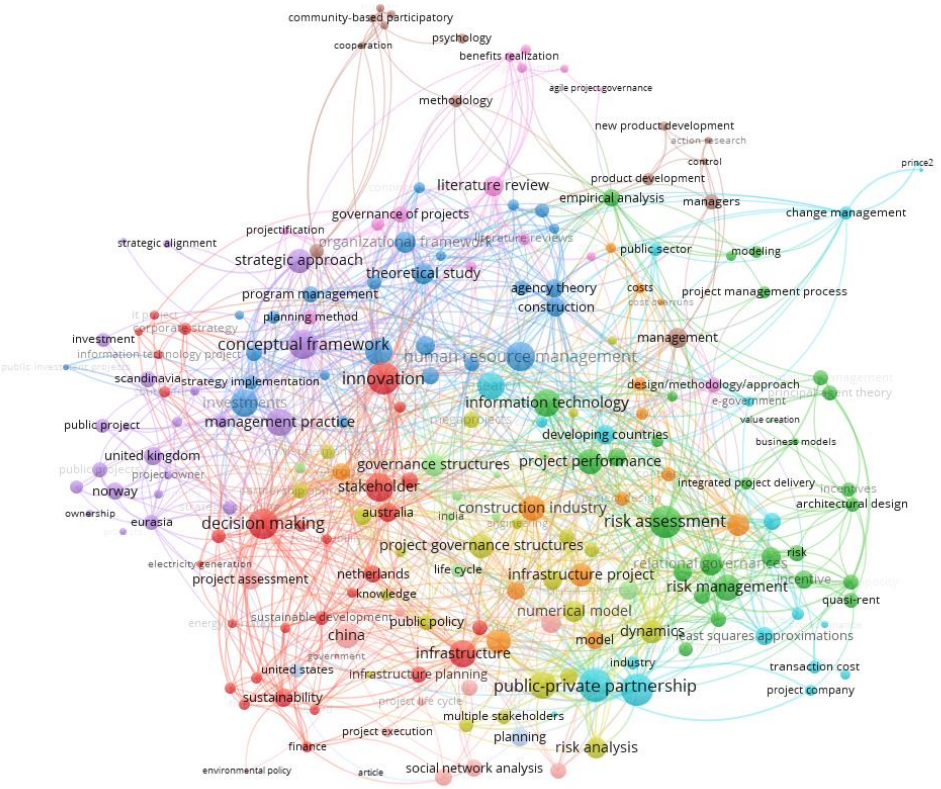

Figure 21 Co-occurerence Keywords Network Dataset 2

To obtain a better overview of the overall structure of the network, as well as to highlight the dense areas in the map, the density view of the network is displayed. In this chart, each vertex has a colour that depends on the weight of the vertex in the network, the number of vertices in the neighbourhood and the importance of neighbouring vertices. The larger the number of vertices in a vertex's neighbourhood and the higher the weight of the vertices, the closer the colour of the point is to red. Keywords that are located in dense areas of the map are shown in red, clearly indicating their important structural role in the keyword co-occurrence network.

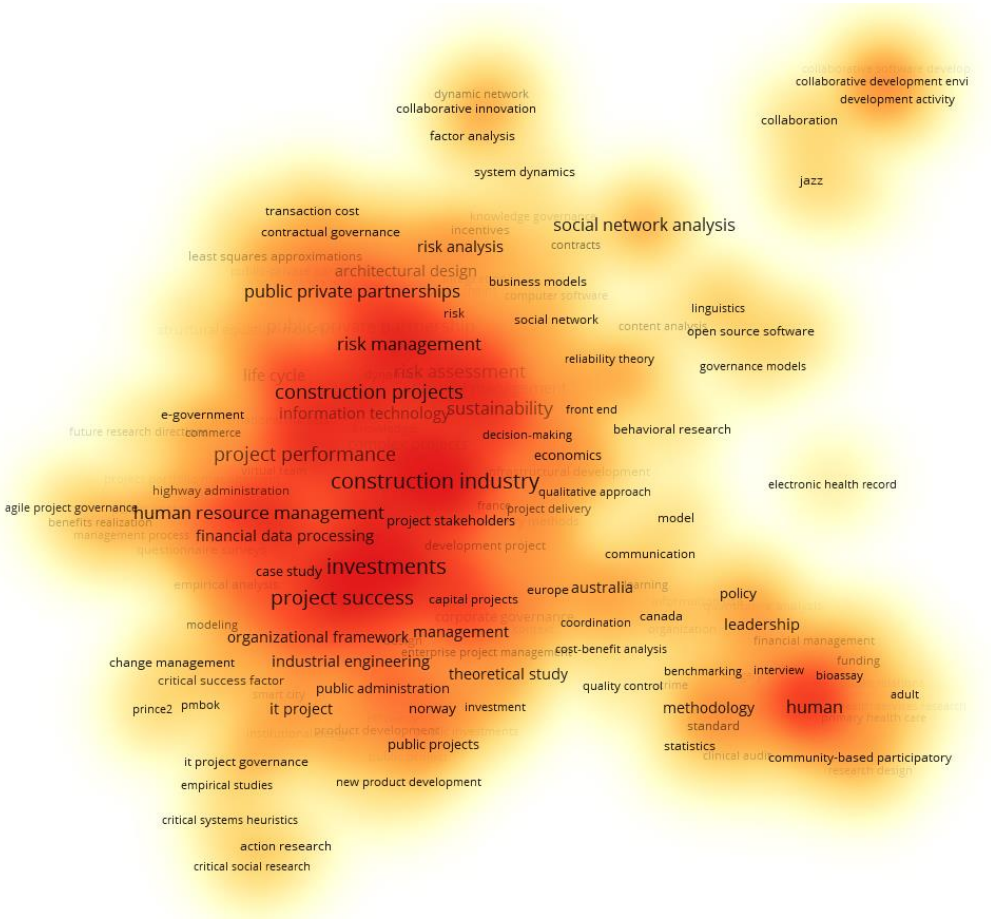

Figure 22 Co-occurerence Keywords Network Dataset 1

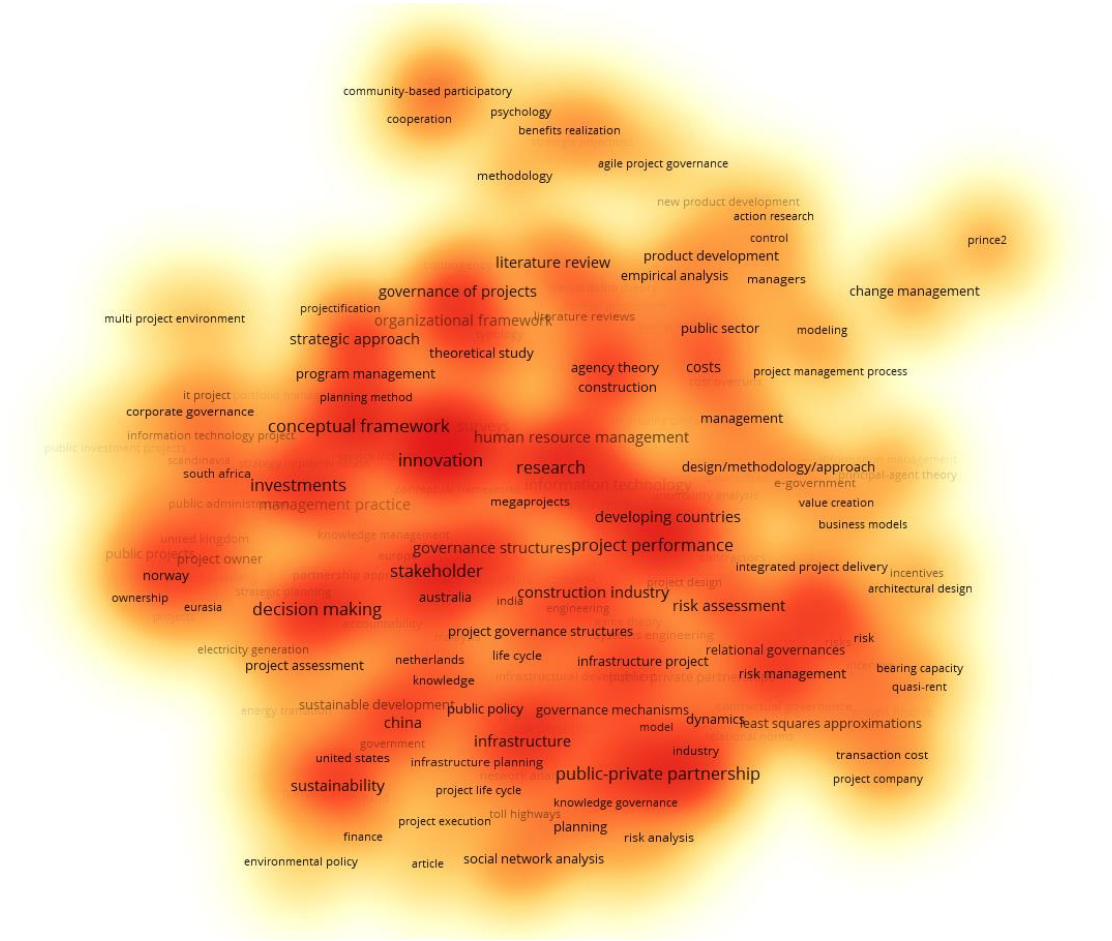

Figure 23 Co-occurerence Keywords Network Dataset 2

The first clear difference between the two networks lies in the presence of the human cluster, which is only present in the first dataset. The concepts linked to this cluster are linked to the social aspect of governance, with concepts such as leadership, cooperation and policy appearing.

Moreover, we find that ‘construction’ appears as a one of the main areas of interest in project governance research, indicating that project governance issues are related to the construction industry with relevance. Construction projects are also the most prominent project type, followed by appearances of innovation and complex projects, and IT projects. The construction focus in project management research may eventually be explained by the project-based orientation of the industry.

When looking at the cluster “Project Performance” in more detail, we find that “relational governance”, “contractual governance” and “governance mechanism” are strictly related, indicating that the general objective of project governance approaches in our research context is to propose a framework that combines relational and contractual mechanisms aimed at reaching better project performance.

Studies regarding performance are primarily associated with topics such as megaprojects, infrastructure, and success. Project governance in megaprojects focus on policy making, managing stakeholders, and top management.

As we can see in figure, one of the keywords highly connected within the bibliographic network is "conceptual framework", especially in journal papers network. This is a crucial aspect, as it underlines the fact that project governance research is currently oriented towards theoretical aspects and less on the practical application of these guidelines in terms of implementation.

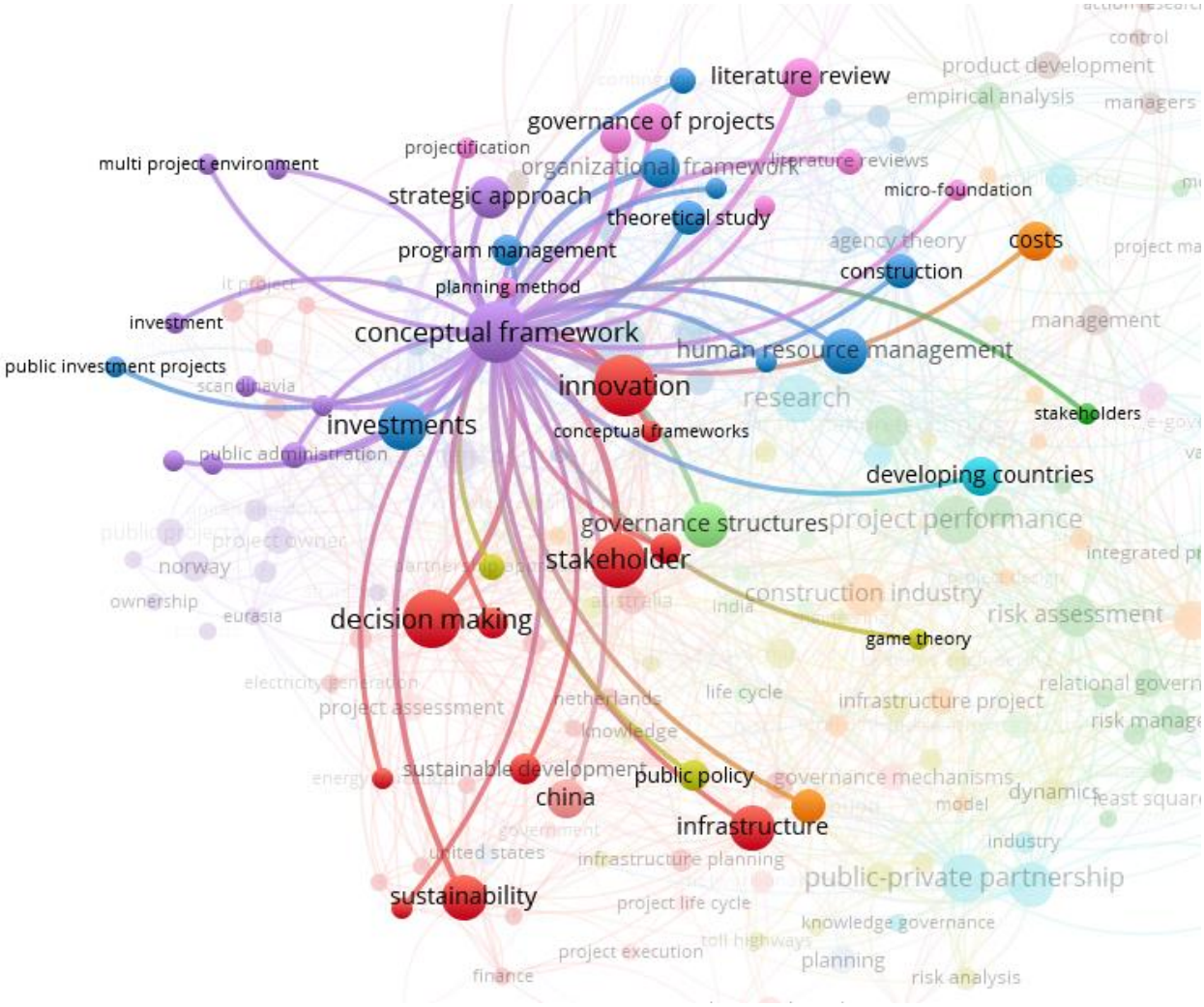

Figure 24

Tools and methodologies seen above are exactly the target of this research, and for this reason they are the most relevant and to be dealt with in more detail.

Among the keywords of the bibliometric network, one keyword seems to emerge that can answer the question of this research. Social Network Analysis appears in both networks as the most significant of the tools to manage governance in a systemic way within the literature, with a clear prevalence in the first network, the more generic one. Also, in the journal articles network of we can also note the presence of SNA, but in this case in a less prevalent way, which would however seem to suggest that publications on this approach are

relevant. What is certainly relevant is the fact that it appears disconnected from the keyword "conceptual framework", indicating that this is a wholly practical approach and that it is not just a question of the conceptual system.

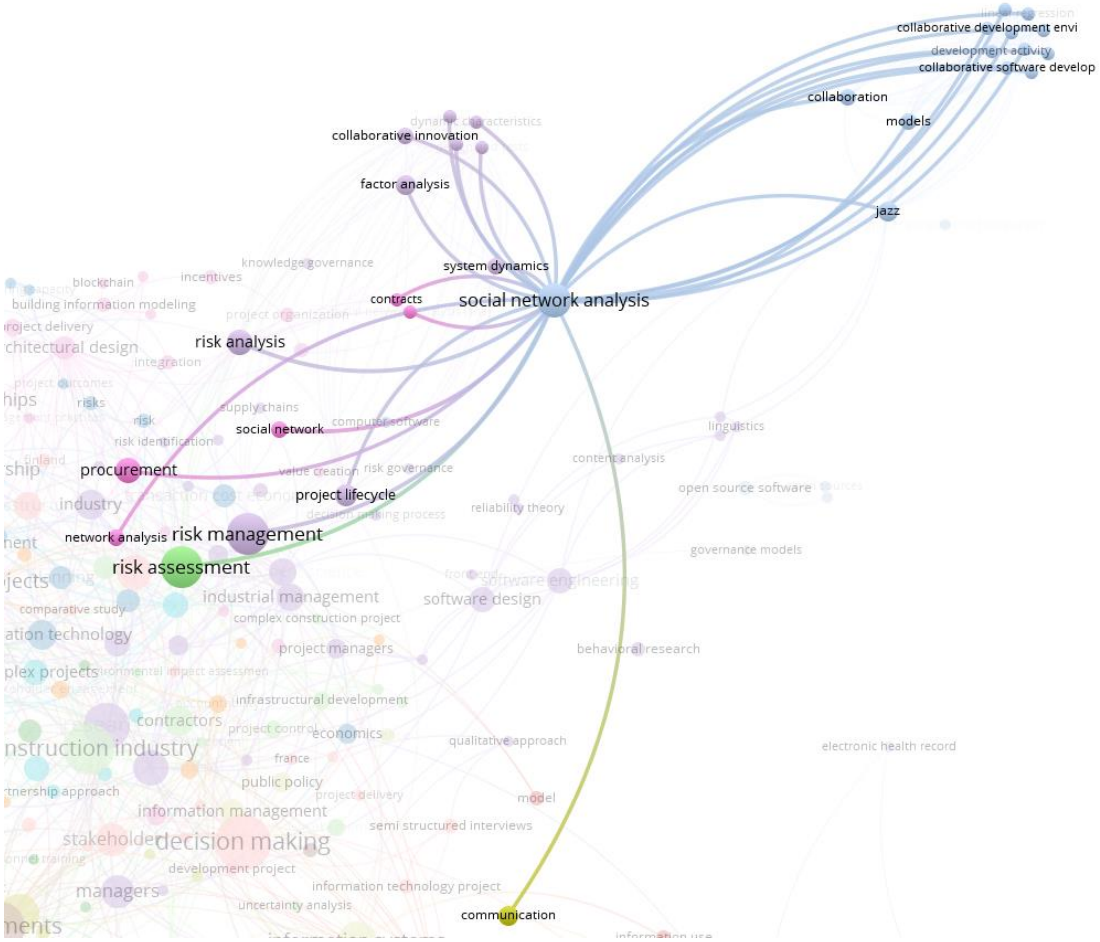

Figure 25 Co-occurerence Keywords Network Dataset 1

Figure 26 Co-occurerence Keywords Network Dataset 2

Considerations

The goal of this bibliometric study was to analyze the application of governance theory in project management research. In this study, we looked at the most active authors in project governance research and identified the main topical areas of the field. We found that governance theory is a prevalent basis for a variety of studies in project management.

Thee most productive and the most highly cited author in project governance is Ralf Müller, and most of the existing project governance research achievements are from USA, China, Australia, and Norway. Regarding the most active authors, it turns out that European authors are the most prevalent in the field, a finding that was particularly substantiated by the analysis of the network of coauthorships.

Some considerations can be made about the presence of social network analysis as a prominent keyword compared to other approaches that we have seen in chapter one. In fact, among the network keywords, approaches such as system engineering and system dynamics are present, but they have a lesser relevance in terms of studies (always keeping in mind that our research field is project governance in its quantitative form). While the number of studies on system dynamics and system engineering is growing, Social Network Analysis is the most established quantitative approach to project governance. As a demonstration of this, one of the most cited studies, defined above as one of the pillars of PG in quantitative terms, is precisely (Pryke S. D., 2005)" Towards a social network theory of project governance". This study consolidated the basis of an increasingly studied governance approach, called network govenance (Jones, Hesterly, & Borgatti, 1997), which aims to study the links between actors within a project. For this reason, Social Network Anlaysis will be discussed in detail in chapter three making comparisons with the mehods analyzed in the chapter one.

Chapter 3

Introduction:

This chapter is grounded in the formative body of work of (Pryke S. D., 2005) who has criticised conventional conceptualisations, analyses and design of project organisations for being inadequate to capture the complexity of today's construction and engineering projects.

The first implementations of Social Network Analysis in project management emerge with the intention to go beyond the so-called 'iron triangle'. Besides monitoring and managing costs, time and quality, project management needs new analysis tools to achieve success in projects.

The social networks analysis is a theoretical-methodological branch of study that deals with the study of social networks, defined as any group of individuals connected to each other by different social ties. The idea at the basis of Social Network Analysis (SNA) is to study, measure and represent social relations between individuals or between groups of individuals.

The use of networks to represent social organisations began in the 1930s: the first sociological studies already highlighted the importance of constructing graphs whose nodes represent individuals, and whose arches represent the relationships between individuals, in order to identify and explore sociometric data, with particular reference to the existence of groups and subgroups in the social network under investigation.

The difference with mainstream social research lies precisely in the importance given to the relationship between two or more subjects belonging to the network. Applied to project management, this approach is defined by Pryke as the relational approach.

Pryke et al. (2017) identify two areas in which research on social networks can be oriented:

- a better understanding of the role of each stakeholder and functions in construction projects.
- an analysis of the effectiveness of relationships in the implementation of successful construction projects and higher organisational outcomes.

Regarding stakeholders, (PMI, 2013, p. 391) points out “while some stakeholders may have a limited ability to influence the project, others may have significant influence on the project and its expected outcomes. The ability of the project manager to correctly identify and manage these stakeholders in an appropriate manner can mean the different between success and failure”.

Social network theory sees an organization as a system of entities united by a variety of relationships (communications, friendships, power, resource flows, etc.) and is particularly interested in the structure, pattern, causes and consequences of such relationships over time. (Scott 2017) describes social networks as

self-organizing, emerging and complex, forming repeatable models of relationships that can be used to understand organizational phenomena, such as project organizational outcomes.

Social connections are not always positive, networks can be maladaptive in responding to environmental change and can concentrate power on those who control networking technologies, bypassing powerless actors and groups and producing suboptimal or even counterproductive results, threats and resistance. Thus, SNA can provide an explanation for both organisational failure and success.

There are different types of social network analysis metrics to measure relationships and structures that reflect the organisational results of a project. The focus of this chapter is to present them in detail. Three are the levels of application of these metrics: micro, meso and macro levels of analysis. At a micro-level, the focus is on the individual actor and his dyadic and triadic relationships within the social setting. Meso-level networks lie between micro and macro networks and focus on the structure and consequences of intra- or interorganisational links, both at corporate and project level. Examples of mesoscopic level are exponential random graph models (ERGMs), scale-free and small-world networks, and network evolution. When organisations are large and complex, various levels of analysis are involved. At the macro level, the SNA focuses on networks at the level of society, government and population. Project networks are generally described through the meso level.

Social network Analysis in Literature:

The growing significance of Social Network Analysis research, since 1970, is well attested by the great number of papers and books connected to it. From 2001, the research on this topic started growing exponentially reaching 16.110 document results on the Scopus database in September 2020.

The growing interest in this approach is attested by the growth of several academic journals entirely dedicated to Social Network Analysis. One of the main resources is the “Social Networks” journal, published by Elsevier Science, that deals with theoretical, methodological and substantive themes, and is characterized by a multidisciplinary approach. Another journal dedicated to SNA is “REDES”. Also available online is “Connections”, the official journal of INSNA.

Research on project networks showed considerable benefits in governance, stakeholder management, the effect of parent company practices and in procurement (Winch, Morris, & Pinto, 2004) (Artto, Eloranta, & Kujala, 2008) (Hellgren & Stjernberg, 1995) (Cova & Salle, 2000).

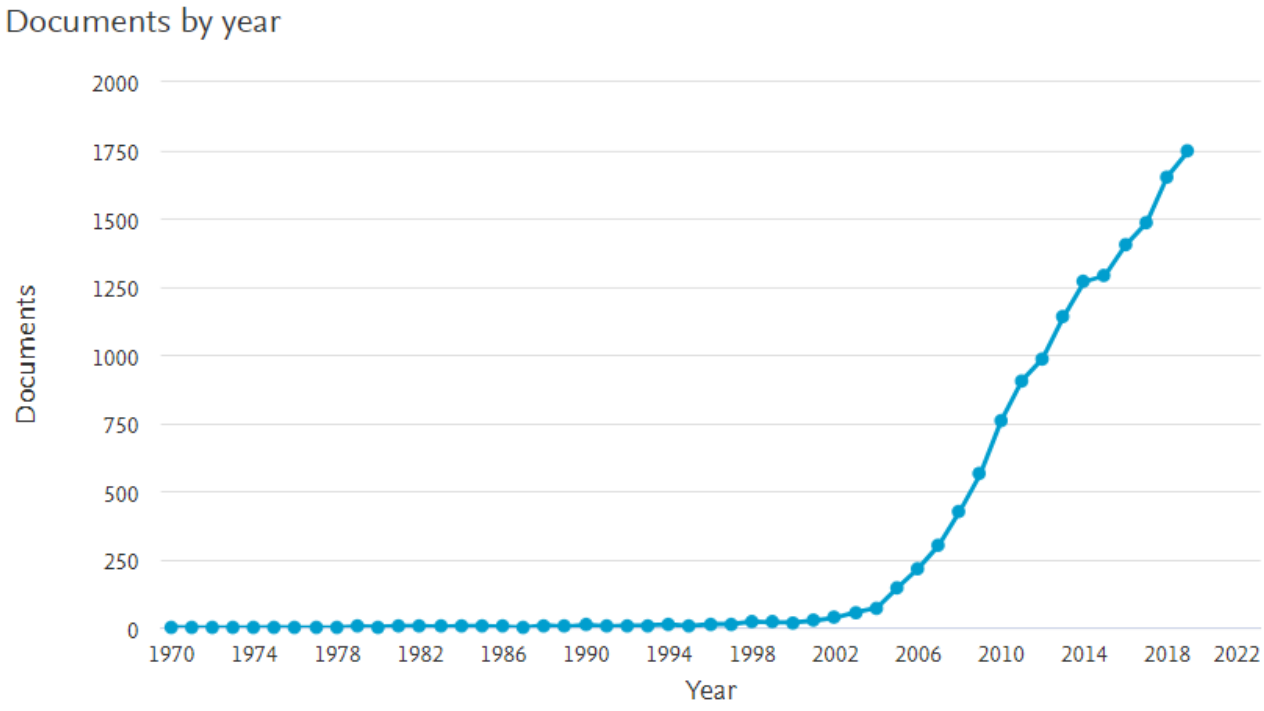

Figure 27 SNA - Number of Documents per year – Scopus

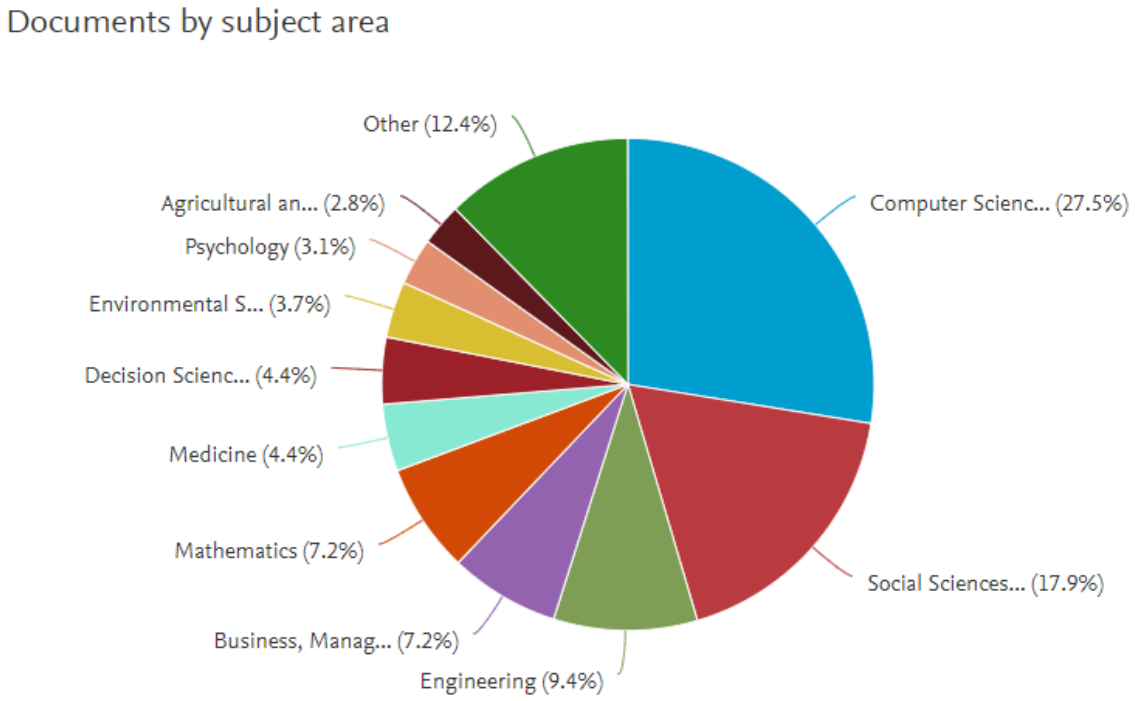

Figure 28 SNA - Documents by subject area - Scopus

Network Enabling

Projects are delivered through relations between companies, organisations and individuals and interpersonal relations, both inter- and intra-organisational. Social network analysis allows us to compare contract conditions, information exchange systems and other forms of project governance using one systematic format (Pryke S. , Social Network Analysis in Construction, 2012).

There are three main levels of analysis to which an organisation's network can be addressed:

- Intra-organisational, interpersonal
- Inter-organisational, interpersonal
- Inter-organisational.

The first category includes interpersonal relations within the organisation/project. In this case, informal hierarchies are studied in relation to formal ones, as well as efficiency in the exchange of information, and human aspects such as trust and personal traits of individuals, which then flow into the behaviour of the network.

Inter-organisational data are usually taken together in the forms of informal-interpersonal data and the formal data and then they are compared. Inter-organisational relationships are frequently formal and dyadic relationships of a contractual nature (Pryke S. , Managing Networks in Project-Based orks in Project-Based , 2017). The focus of the study of such network relationships is to reduce the emphasis on the conflictual and corrective aspects of contracts, focusing instead on how to create more collaborative relationships in which the emphasis shifts to relational agreements, sometimes in parallel with formal dyadic contracts. Some relevant topics within this area of investigatin are stakeholder management, contracts, procurement and supply chain.

Intra and inter-organisational

When applied to corporate environments, Social Network Analysis is also called Organizational Network Analysis (ONA), with the aim to guide change processes. The basic idea behind the use of the ONA, is that the traditional organisation chart, based on the linear and hierarchical chart, does not describe what actually happens in an organisation at the level of relations among its members.

Pryke et al. (2017) argue that the focus of research on social networks in construction should be firstly a better understanding of the role of individual actors and functions in construction projects and secondly an exploration of the effectiveness or not of relationships in delivering successful construction projects and improved organisational outcomes.

Project relationships are also contingent and context-specific and increasingly sophisticated, calling into question the effectiveness of traditional approaches to project management predicated on linear models which ignore these relational complexities.

The informal network, although initially underestimated, represents a great potential for the organisation to which it is applied. The projects are defined and characterized by numerous types of interorganizational, intra-organizational and interpersonal relationships with multiple dimensions such as communication, friendship, power and social. Also project relationships are contingent, context-specific and increasingly complex, and question the validity of conventional methods of project management based on linear models that ignore these relational complexities.

The ONA can provide information on how to improve the performance of the organisation, representing the picture of the real relationships among the actors of an organisation and defining in a clear and univocal way who is in contact with whom, together with specific characteristics of the actor (sex, age etc.) and type of relationships (intensity, duration, flow of information).

When applied at a project level, the ultimate goal of network analysis is to implement actions to optimize the network among stakeholders. The most important assessment is to identify which connections add value to the project, and which ones represent background noise and thus make it more difficult to carry out the project itself. The key connections to focus on are those that help in making decisions within complex contexts. In particular, attention should be paid to looking for potential connections that could improve the overall project performance. Subsequently, in order to create these new value-added connections, various activities such as team building can be planned.

When looking at the sociogram it is logical to expect some key figures to be hubs for the project, e.g. the Project Manager should be central and well connected with other project members; the Project Sponsor should be well connected with the Project Manager and strategic decision makers, and so on. What the Social Network Analysis can highlight are those situations where a person conceptually and contractually identified as a hub is not and is bypassed on the map, and the expected connections are related to someone around. For example, when project members go directly to the Project Sponsor for decisions, bypassing the project manager. In these cases the options to be considered may involve carrying out team building activities with specific members, pushing on the networking of the non-hub person, preventing the unwanted hub person from being in contact with the rest of the team, for example selecting phone calls and excluding other contact attempts until the network adapts to using the designated person to make decisions. Another option is replacing the people responsible for the sub-optimal situation.

Other actions must be taken to improve the flow of information through the network, identifying and resolving information and decision bottlenecks, and areas in the network where increased information flow can have a good impact must be found. Underutilised resources are typically identified among those peripheral to the

network and with few connections. Those subgroups that do not work in synergy with the network should be stimulated to expand their relations with the remaining units.

Some metrics to assess the effectiveness of changes may be the time required by information to propagate through the project, or the time required by a decision to be made. It is also possible to create a benchmark with the results of analyses obtained on several projects in order to compare the best forms of the network and identify any differences in form.

The ONA plays a key role in portfolio management. Through some metrics it is possible to evaluate the intrinsic complexity of the projects in a portfolio, by assigning a score that reflects the number and intensity of the internal connections to the project network. In the same way, the external complexity of a project can be evaluated by referring to the number and intensity of connections to other projects. This makes it possible to identify critical projects based on their complexity and not just in terms of total cost.

Numerous studies have shown the contribution of networks to the institutionalization of fields through the diffusion of practices, which depends on the sociometric position of an actor in the field and the proximity between actors (Clegg, Mehra, Josserand, & Pitsis, 2016).

In summary, networks do not have a hierarchy. Roles emerge according to how actors interact and are therefore not solely predetermined by contractual or formal agreement. The responsibilities determined at the beginning through project definition meet the transitional nature of networks, which tends to result in constant reassessment and response cycles. Actors' responsibilities evolve bypassing formal top-down control in response to the increasing complexity of projects. The consequences of this process are related to the development of roles that are not appropriate or undesirable for the network. The same process can be seen under the informal aspect, where status, power and authority are assigned or endorsed and supported by other network actors and refer to the emerging network configuration, which emphasises one particular network actor over another.

SNA and Project Performance:

As regards the field of project management, namely the domain on which the present work moves, it is possible to identify an initial reflection on SNA regarding governance in the work of Stephen D. Pryke, who placed at the centre of his reflection "actor centrality", that is the importance of an actor within a network.

For the author, the relationship between objects becomes an object of sociological analysis when a relational configuration based on the reciprocity of exchange is determined: "as a regulating principle of the world we must assume that everything is in some relationship of interaction with everything and that there are constant forces and relationships between every point in the world".

Many other authors have analyzed the value of SNA on Project Governance, highlighting that it has a positive impact on the project performance.

(Pryke S. D., 2001) has shown how construction management forms bring more efficient communications than traditional patterns of contracting.

(Clegg, Mehra, Josserand, & Pitsis, 2016) argue the necessity of "a more pragmatic approach to the study of networks, one that blends structural analysis with theoretical perspectives that are more attentive both to agency and to the symbols, meanings and values that make up cultural discourses in which networks are themselves embedded".

(Zarei, Sharifi, & Chaghouee, 2018) have seen network analysis as a tool for a more complete understanding of the main causes of delays in complex projects, enabling a better analysis and mapping of the interrelationships between these crucial factors. (Zhang & Fang, 2018) using social network analysis demonstrated the absolute central position of the owner in construction projects, as a large betweenness centrality value implies a strongest control advantage in the network organization of the project.

Since 2000, social network analysis has emerged as a key model to analyse organisational behaviour in large and complex projects and to provide a more holistic and relational picture of project organisations, in particular in construction field. (Zheng, Le, Chan, Hu, & Li, 2016) highlight the need for an effective network analysis tool to examine the interrelated elements involved in complex projects and interdependencies for formulating project-management strategies, finding in SNA the proper tool. Among them, (Li & Lu, 2009) built a model to analyze subgroups of complex project management based on network analysis. Lastly, relevant analyses have found strong capabilities of network analysis in several fields found in construction projects, such as: performance and effectiveness; communication and coordination; knowledge management; risk management; governance issues; strategic management; use of information technology and diffusion of innovation; and site and resource management. (Zheng, Le, Chan, Hu, & Li, 2016).

Network analysis is a potential tool in project control. (Perrier, Benbrahim, & Pellerin, The core processes of project control: A network analysis, 2018) examine PMBOK and PRINCE2 most important control processes using network analysis. The rationale of the research is that each process has inputs and outputs, and an output from a process can be used as an input to another process. The "Take corrective action" activity was identified as highly central to project control in the PRINCE2 network, while its PMBOK counterpart, "Perform integrated change control" also had higher centrality. Also, they demonstrate another time the major risks associated with any project are cost, time and quality.

SNA can complement other research methods for examining uncertainty elements, which are nonsocial structures in complex projects. (Lee, Chong, Liao, & Wang, 2018). Others suggest approaching SNA to integrate a link probability model, such as the Monte Carlo simulation method, to provide a more accurate prediction for network data.

The reasons behind adopting Social Network Analysis

Within the literature, it is possible to identify 4 main reasons for adopting Social Network Analysis.

1. Every organisation represents a social network and as such has to be analysed as a set of nodes connected by social relations. Relations can be classified into formal or prescribed, emergent or informal, relations based on friendship, advice or conversational aspects etc.

2. Social network analysis can be applied not only at the level of the individual company/project, but at the level of the whole ecosystem of organisations with which it comes into contact. In this case, the most significant elements at the level of analysis are the other organisations with which they have to transact. In order to have a global and quantitative view of the internal stakeholder network, a means of describing and quantifying the relationship between all organisations is needed. The relationships are multiple, complex and overlapping, making it difficult to see the overall pattern from a single organisation. In order to detect overall structures, the scope of analysis needs to be broadened at the inter-organisational level to include key suppliers, consumers of resources and products, regulatory agencies and competitors.

3. Interactions of actors in organisations can best be explained in terms of their position within networks of relationships. It is then necessary to consider the position of an actor and the attributes of that position in order to gain a comprehensive view of their actions. Networks constrain actions and in turn are shaped by them, resulting in dynamics in that actors can change their positions in networks and create new network sections around them. A network could thus be cosidered as a snapshot of a dynamic system rather than a static representation of a structure of authority relations. actors' positions within networks of transactions provide a measure of quantifiable change in both the organisational form and the actors' roles within that form.

4. The comparison between organisations has to take into account their network properties. For example centrality, is a measure of the average degree of asymmetry in relationships within an organisation or project, and the extent to which decision-making rights are concentrated among a few individuals.

Data Gathering

Social Network Analysis is the result of the collaboration between mathematicians, sociologists and anthropologists. However, the word 'social' should not deter us from using the method to explore the non-social aspects of projects. SNA is primarily a method of structural analysis, allowing for the mathematical, and therefore quantitative, analysis of what might otherwise be considered purely qualitative data.

SNA is a quantitative tool capable of being applied within an interpretive context in complex projects. Literature exponents such Smyth have argued that qualitative and quantitative approaches can be integrated with the idea that combining extensive and intensive methods is more important than thinking in a quantitative–qualitative dichotomy. The first step in this process is to map a flux of information in the shape of a network and after that try to measure on it some particular property. This flux of information can be represented by any exchange of data that takes place within the network of the project and its stakeholders, such as email, payments and so on. Another experimental method is to create a specific questionnaire to collect social network analysis data.

Figure shows an extract from a questionnaire used by (Pryke S. , Social Network Analysis in Construction, 2012), where each actor is asked to report from whom he receives information. Each category to be given a value between 1 and 9 to reflect perceived frequency, followed by a similar rating for perceived importance of information exchange. Each category to be given a classification of nature of information: A instruction; B advice; C information; D discussion (non-directional communication). No distinction is made between various modes of communication.

Actor			Nature of information exchange				
Ref.	Name	Role	Building use	Specification	Progress	Budget	Costs

Finally, we can compute the centrality measures on this oriented network getting the most central nodes. In this case the simple interpretation is that the top ranking actors are very likely the most influential, in relation to the selected topic.

By representing a complex system through its network, we are able to better visualize the system and observe the interconnections among the various nodes. In order to be better understandable, a network is represented as a graph. A graph can be described as a mathematical representation of networks which acts as a framework for reasoning about numerous concepts.

Metrics in SNA

Research in the SNA domain since the 1980s has yielded many important social structure measurements that have been linked to organisational/project outcomes, accompanied by well tested metrics and methodologies to measure them, some of which have been deployed in the field of construction management to explain the construction project performance. We can classify them into four knowledge areas depending on the role of each network:

- The formation mechanisms of a network
- Centrality
- Connectedness of a network
- Network topology

Formation mechanisms of a network

This type of metrics is related to the status of a node and the degree of node power as represented by ties in a network.

A *Direct Tie* measures the number of direct links from one node to other nodes, while an *Indirect tie* measures the number of links of a node that can be reached through the nodes immediate to it.

Network Density is a measure of how well a network is connected. The number of interactions is the proportion of direct links in a network in relation to the number possible. The value of the density is between 0 and 1, and the larger the value, the closer is the link between the nodes. Density of the network represents the close degree of relationship between the actors (Zhang & Fang, 2018).

Tie Strength is a measure of the strength of a relationship between two nodes. At this level, of absolute relevance is (Granovetter, 1973) with the theory "The Strength of Weak Ties". The main characteristic of weak ties in social networks is that they have a structural significance as generators of connectivity, as they tend to be bridges connecting distant clusters within social structures. This is because, as networks become denser, information becomes quickly redundant such that everyone in the cluster knows that the others know. New or novel information must hence come from weak ties.

Centrality metrics

Centrality is used to indicate the centre of a network, reflecting the distribution of relationships through it. The centrality of a vertex or edge is generally perceived as a measure of the importance of this element within the whole network, also defined as prominence. There are various ways to address these two issues and for that reason there are different measures of network centrality available. In a network with a high centrality, only a small percentage of the nodes will have a high percentage of relationships with other nodes in the network.

Depending on whether an actor has more incoming or outgoing ties in a network, the actor is said to have a high in-degree or high out-degree centrality.

(Lee, Chong, Liao, & Wang, 2018) demonstrate how network density, degree centrality, and betweenness centrality are the most influential measures in the analysis of complex project networks.

Degree (or Point) Centrality represents the maximum degree of a node given by the number of nodes in the opposing set (Borgatti and Everett 1997), allowing to show the structural position of actors in a network. Degree centrality can be defined as a "local" measure since it can only be computed by checking the vertex itself and, in most cases, it represents a fast and reasonably accurate quantity to describe the importance of vertices in a graph. There is a further subdivision that becomes relevant here, namely in-degree and out-degree centrality. The former refers to the incoming links, the latter to the outgoing links. High degree centrality of a given actor within a network implies a high level of prominence in an information exchange network or other type of communication network. Degree centrality is relatively high if a given actor has a relatively large number of primary connections. At the interpretative level, degree centrality shows the influence of an actor over the others.

Closeness centrality is used to measure the average length of the shortest path from one node to all other nodes. This measure tells us how good actors are in broadcasting or sharing information. If the total distance is shorter in the network, the closeness centrality will be higher (Zhang & Fang, 2018). In other words it represents the speed with which information can reach other nodes from a given starting node. This metric, unlike degree centrality, is non-local since we need to inspect the whole graph to compute it.

Figure 29 Closeness centrality

Betweenness centrality is another "non-local" way to measure the importance of one vertex or edge is to check how often we visit it when walking on the network. The social interpretation of this measure is brokerage, telling us how good actors are in serving as intermediaries. An actor with a high betweenness centrality value has some control over the network as other actors depend on this actor to connect to each other, as in the case of brokerage. Betweenness centrality is used to measure the control advantage of a single actor, it indicates how much degree that one point is the ''intermediary'' to another points in social network graph. In the context of information exchange, betweenness centrality might be important if efficiency of information flows is an issue (Pryke S. , Social Network Analysis in Construction, 2012). Betweenness centrality is also particularly useful in the case of community detection.

Figure 30 Betweenness centrality

If there is a structural hole (a form of discontinuity in the flow of information) in a network, the person holding the brokerage position can capture a strategic position to connect or disconnect nodes in a group, and thus, enjoys a competitive advantage relative to other nodes (Maoz 2011). The degree to which an actor sits between clusters in a network. Actors with high betweenness act as gatekeepers and values within a network, controlling the flow of information between others.

In the social network analysis, actors such as project managers who play important bridge roles are those who have a high "betwenness centrality" and form relationships that transmit information from one organisational cluster to another (Scott 2017).

Bonacich power centrality: refers to actors who are tied to central actors who have higher prestige or centrality than others (Bonacich 1987).

PageRank: is another centrality measure that counts both the quantity and quality of the followers of a node to determine the degree of influence of that node. PageRank was developed by Google to rank web pages.

Geodesic distance is the shortest path between two vertices, thus the diameter is the longest geodesic distance between any pair of nodes.

Average path length is a measure of the efficiency, as the path between two nodes becomes shorter, the efficiency with which information is transmitted will increase. A graph theory-based measure that indicates either the distance between the two nodes with the greatest separation in a network, or the distance between two specific nodes in question. A measure that can indicate either the distance between two general nodes with the greatest separation in a network or the distance between two specific nodes in question. For example, a project network with a large geodesic distance between a structural engineer and concrete subcontractor means that many parties will transfer a request for information between the two parties before an answer is originated and returned. (Kereri & Harper, 2019)

Eigenvector centrality: is a spectral centrality measure. This measure gives us information about an actor on the basis of the relations he has with his neighbours, i.e. his closest contacts. Can be defined as an extension of degree centrality and is proportional to the sum of the centralities of the node's neighbors (Estrada and Rodríguez-Velázquez 2005).

Figure 31 Eigenvector centrality

Status centrality (also known as Katz centrality) is similar to eigenvector centrality in that it also reflects a stakeholder's influence within a network. It measures the number of direct successors ad predecessors of a node as well as the secondary nodes that are indirectly linked to the focus node via the node's immediate neighbors (Katz 1953).

Connectedness among actors and subgroups in a network

Clustering coefficient: at the node level, is the percentage of two paths in a network that are close (de Nooy et al. 2011). Clusters represent the parties that are more frequently, reciprocally and closely connected (through the number of links) with each other than with others. Clusters are identified to visualise organisational functions where there may be important obstacles and opportunities for communication within networks.

Structural equivalence: if two actors have similar connections to other actors, they are similar or equivalent. This is an important indicator of collaborative relationships, but it can also result in a waste of resources, as two agents with the same links are considered interchangeable and play comparable roles in their networks.

Reciprocity: is the ratio of the number of reciprocated node pairs to the number of connected node pairs (Lee et al. 2016).

Transitivity indicates the possibility of a node A to have a connection with node C, if A knows B and B knows C. It is the proportion of triads and the number of triples (Bruggeman 2013).

Point connectivity represents the minimum number of nodes that must be removed from the graph to cause the graph to become disconnected (Wasserman and Faust 1997).

Partitioning is used to classify the nodes in a network (de Nooy et al. 2011). It involves the assignment of a similar color to nodes or edges that share the same values for a given SNA parameter or node/edge attribute (Hernández-García and Suárez-Navas 2017)

Modularity measures the strength of the division of a network into modules (groups or clusters). It distinguishes the number of existing links in a partition and the expected number of links that could appear between the nodes of the partition (NikBakht and El-Diraby 2016).

Homophily explains how, when offered a choice, people prefer to choose others who are similar to themselves (Kleinbaum et al. 2013).

Core relationship When the relationship between the nodes is compact, it is said to form a core. When the relationship between the nodes in another group is loose, it is regarded as being a periphery (Chang and Zhang 2013).

Boundary spanner is another term that is typically used to describe the role of an actor as a mediator to ameliorate negativity from differences of statuses and cultures among the nodes.

Network Topology

The pattern in which project team members are connected in a network presented visually to interpret its emergence and meaning. In construction three are the main models of network studied: random network, small world network and truncated free network.

Component: is a maximally connected subnetwork (de Nooy et al. 2011). A giant component represents the largest isolated subnetwork, which is usually identified in a random SNA network (Liu et al. 2015). Represents the network connectivity degree, which is calculated by a subset of nodes interconnected by edges/relational tie.

Random network: These are networks in which individuals can access each other freely without any form of clustering. Consequently, the average path length between members is quite short because the links are not direct.

Small-world networks: most nodes are not neighbors but can reach each other in a small number of steps. This concept is closely related to the notion of weak ties described above, since these ties enable distant clusters to be linked. There are two major differences between this model and the random network. The first concerns the mechanism of network formation, which in the first case is causal within the population whereas small world networks are formed on the basis of socio-cultural constraints, i.e. relationships develop when people have something in common Thus, individuals having characteristics comparable to each other are clustered together while individuals with dissimilar characteristics are kept away from the network Therefore, small world

networks show a high density inside clusters whereas the average path length in social networks increases. The second difference to random networking is that small world networks are a fragmented network from cluster to cluster, bridging ties are needed to connect two clusters. Furthermore, more bridging ties are needed than in the random network to reduce the average path between any two individuals (Watts 1999). As the average path length between individuals increases, so does fragmentation. Average path length and clustering coefficients can be used to demonstrate the level of fragmentation/integration. In small global networks, it would seem that individuals in the network develop new skills and knowledge more efficiently, and engage with new technologies.

Scale-free networks: This scale-free network has a degree distribution determined by the social group's size distribution. They are very dynamic and growing networks where new members join the most connected members. The two main features of truncated scale-free networks are:

- Clustering coefficients are larger than in random networks, which implies that team members add a link one at a time and these links will connect to a team member with many other team member links;
- The diameter increases as the number of vertices increases. The diameter represents the amount of information transported through a certain link.

Truncated free-scale networks exhibit all the properties of small-world networks, but this is not the case for small-world networks, which do not necessarily exhibit truncated free-scale networks. A truncated ladder network would be established in construction projects when a firm seeks partnerships with firms that have a good reputation or possess many resources.

Egocentric networks: is a personal network.

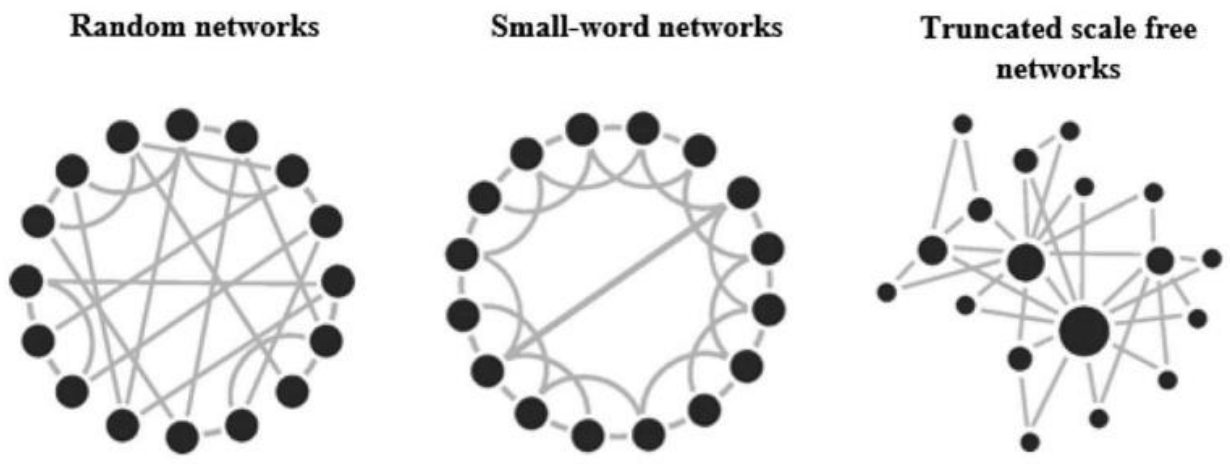

Figure 32 Source: Anderson et al. 2014, © ASCE.

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(Kereri & Harper, 2019) points out that construction project teams emerge as small world networks through the clusters formed as a result of either contractual or trade relationships. However, to understand the interaction between team members, social networks account for the social ties that do not have any formal authority recognized by traditional project contracts. To improve performance in construction networks, project team members need to break clusters by forming links to other team members in another cluster. Forming links will enable team members to access information and resources necessary to improve their performance. Very dense or very sparse networks are not good for efficiency and thus not characteristic of high performing teams. For increased performance, team members need to gain strategic locations by breaking constraints that keep them in a particular cluster either through use of technology-based tools or by freely seeking social relationships with team members who have either complimentary resources or information. To this end (Kereri & Harper, 2019) hypothesize that truncated scale-free networks are less vulnerable to failure as compared to either random or small world networks, and recommend that construction researchers explore this hypothesis.

Trust in networks

The distinction of in-degree and out-degree, together with the density of the network, enables us to measure the level of trust within the network. Within a project, actors continuously filter the information they process as part of everyday life. Trust affects the extent to which filtering, processing or dissemination takes place, and the time and extent to which these can be abandoned due to time pressure. Low levels of trust in a project network result in low levels of density in communication networks. Conversely, networks become denser when actors need information and the time to find it is limited. Therefore, to calculate the trust of a network it would be appropriate to isolate the effects of time pressure. Beyond network density, the trust of a network is reflected in the prominence (centrality) of a given actor and the distinction between in-degree and out-degree centrality values.

Simplifying, an actor with a low trust value can be identified by a high value of out-degree centrality to which correspond low values of in-degree centrality of the actors with whom it communicates. This can be explained because this actor feels confident in disseminating information, but the other actors try to reduce their in-degree centralities to deal with this low trust value information.

Consequently, a trust-oriented governance approach should favour the establishment and maintenance of high levels of trust and seek to create networks with an absence of extreme levels of prominence. Diversity in levels of prominence can tend to affect trust-building.

A democratic network is reflected in low levels of standard deviation in point centrality, eigenvector and betweenness centrality for the actors in the project. By contrast, an autocratic network has a small number of very prominent actors with a wide variation between in-degree and out-degree centrality.

Social Network Analysis and System Dynamics

Social networks are a special kind of complex networks, limited to individuals and organizations. Social network analysis is a quantitative method used within an interpretative context. The underlying premise of social network theory is that an organisational phenomenon can be better understood by looking at the structure and type of connections among the entities, instead of studying the properties of the entities themselves. One of the majour drawbacks is indeed that Social network analysis deals with analysis but does not always provide causality.

One approach that is evolving in an increasingly relevant way seems to be the use of social network analysis in combination with tools capable of simulating the dynamic behaviour of the system. Not surprisingly, the two theories that have been most frequently encountered in recent papers are precisely those that attempt to reconcile social network analysis with system dynamics. System dynamics is more interested in the behaviour of the system and not in the structure itself.

(Ding, Wang, Gao, & Sun) point out that Social Network Analysis is the representative method in the organisation dimension that quantitatively evaluates the governance network formed by stakeholders and their relationships statically. However, they argue that SNA does not satisfy the dynamic characteristic of the network that is caused by risk factors, since SNA quantitatively evaluates the network statically and the governance network in organization dimension is dynamic. As a solution, they present a new method based on the integration of SNA and system dynamics, called Network Dynamic Analysis (NDA). The framework is a risk management process with five phases based on the classical risk management: (1) governance network identification; (2) governance network assessment; (3) governance network analysis; (4) risk response planning by adjusting governance network; and (5) risk monitoring and control.

(Enos & Nilchiani, 2018) use SNA to enable the identification of potential systems of systems that emerge from the larger network of systems.

(Schoenenberger & Schenker-Wicki, 2015) state that System Dynamics and SNA can be combined without losing theoretical consistency. They argue that the problem with representing a model of a dynamical system as a directed network is that one neglects its dynamical complexity that emerges from non-linear relationships and accumulations, focusing instead on its structural complexity. However, they argue that although “one of the fundamental assumptions of systems dynamics is to emphasise that the behaviour of the system arises from its underlying structure, since undesirable or pathological system behaviour can often only be altered by changing the structure of the system, having better tools to understand and simplify structural complexity allows for a more efficient policy design process”.

Conclusion

The aim of this research is to try to identify the 'intellectual structure' or 'knowledge base' of the scientific domain of project governance, assuming that the future advancement of a field depends largely on existing scholarship and the work of contemporary contributors generating new knowledge.

The application of network theory is really multidisciplinary and faces similar problems across the various topics. The purpose of developing a network perspective is to reduce the complexity of a system to a series of well-defined subsystems that can be understood and then managed synergistically using existing processes and procedures.

Literature suggests social network analysis as the major quantitative tool to identify interesting new phenomena, provide alternative perspectives to complex problems and gain a richer and more holistic understanding of complex project management problems. Also, it improves the project performance with a better definition of the responsibilities of the main stakeholders involved. Lastly, social network analysis seems to be an effective approach to address the gap in understanding of how patterns of social relationships between project actors determine project outcomes.

The most obvious application of SNA is in projects that are large and complicated. However, smaller and less complex projects can also benefit from the application of sna principles. The successful delivery of projects, especially large and complex ones, requires any number of factors to be properly addressed and project governance is only one of them. However, what can be said is that using SNA as a systemic governance tool, these organizations are now much better positioned to make efficient and effective decisions that support the successful delivery of their projects.

Finally, SNA is proposed on the basis that it is not used as a method to the exclusion of other methods, but rather as complementary method of existing governance theories and methodologies such system dynmics and system engineering.

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Appendix

List of Documents

Author(s)	Title	Year
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