Multi-level strategies for supply-chain performance in megaprojects: A systematic literature review and research agenda

Gustavo da Silva Stefano[1], Juliano Denicol[2], Tim Broyd[3], Andrew Davies[4]

[1,2,3,4] School of Construction and Project Management, University College London, United Kingdom;

[4]Science and Policy Research Unit, University of Sussex, United Kingdom;

[1]gustavo.stefano.20@ucl.ac.uk; [2]juliano.denicol@ucl.ac.uk; [3]tim.broyd@ucl.ac.uk; [4]andrew.davies@sussex.ac.uk

Abstract

This research presents a systematic literature review (SLR) on the supply chain (SC) strategies and practices to improve megaproject performance. We propose a multi-level perspective for such endeavours to represent its structure as usually identified by the literature. Drawing insights from the multi-level nesting arrangement presented by Hitt et al. (2007), the megaproject supply chain is conceptualised in the intra-, inter-, and macro-levels of organisations and networks, as a multilayer structure composed by temporary and permanent organisations. An extensive list of terms was created to gather most out of the literature from the fields of operations and project management. A total of 2,210 abstracts were analysed and 94 full papers were selected for this study. Those papers were completely analysed to understand the levels that are related with the application and operationalisation of SC strategies. Six main categories were derived from the literature, namely: inter-firm collaboration and coordination, governance, procurement, projects as networks, production & logistics strategies, and risk management. Those categories are further detailed in subcategories and their relationships are explored, described, and depicted in the study. Finally, the multi-level megaproject supply chain (MMSC) framework is proposed, based on the analytical codes and categories derived from the SLR, presenting the strategies and practices at the intra-, inter-, and macro-organisational levels.

Practical and theoretical implications are discussed and several future avenues of research are suggested to conclude the research.

1. Introduction

Temporary organisations can be understood as set of the activities and practices of corporate actors who pursue common task objectives, agreed beforehand, within a prearranged timeframe (Bakker et al., 2016). Projects are often conceptualised as a type of temporary organisation and treated as a network or organisations aligned to an overall goal (Sydow and Braun, 2018). Within the context of project management and temporary organisation studies, megaprojects have increasingly gained space in research given the rapid growth of such ventures around the globe in recent decades (Hu et al., 2015; Flyvbjerg, 2014). Such endeavours are interorganisational, complex, and large, usually costing more than US$1 billion and requiring long-term effort to develop and to build (Merrow, 2011; Flyvbjerg et al., 2003). However, the temporal aspect of megaprojects differs from that of other traditional projects. According to Brookes et al. (2017), since megaprojects have long initiation and delivery phases – which last years or even decades –, building capital assets that can be used for many years, they cannot be framed as the traditional “temporary organisations”. Given the long-lasting time of such projects, they may even look like a stable, almost permanent, organisation. However, from within, there is a complexity of multiple, dependent, and interorganisational subprojects with several stakeholders to be managed (Van Marrewijk et al., 2016; Van Marrewijk, 2005).

The complex temporality of megaprojects poses as a challenge to the interorganisational network of suppliers and its effective supply chain management (SCM). Fernandes et al. (2018) state that the unique nature of such temporary organisations should receive attention when trying to understand the various aspects of the supply chain. However, the application of SCM in temporary endeavours has been proven challenging due to the difficulty of establishing standard processes and procedures (Ballard and Howell, 1998), which is maximised in megaprojects with their own internal economy (Lenfle and Söderlund, 2019), system of production (Davies et al., 2009), and governance

structure (Miller and Hobbs, 2005). As infrastructure megaprojects consist mostly of organisations from the construction industry, its supply chain is characterised by being highly-fragmented, with a low level of information flow and communication, often one-off customised projects, and temporary supply chain structures managed project by project (Azambuja and O'Brien, 2009; Gosling et al., 2013). Given that there is still a productivity gap between construction and other industries, more research is needed in megaproject environments to understand how well-known manufacturing strategies and practices for performance improvement can be applied in in such temporary supply chain structures (Gosling and Naim, 2009; Denicol et al., 2020). In other words, as Denicol et al. (2020) suggest, there is a need for more studies concerning how traditional production and supply chain strategies can be applied to increase the performance of megaprojects. Within this context, operations management (OM) and project management (PM) are prominent areas that can contribute to the discussions and the development regarding the management of megaproject supply chains. However, with regards to the subject of discussion, they still diverge in concepts, terminologies, and perspectives (Ahola, 2018; Thomé et al., 2016; Gosling and Naim, 2009). Therefore, this research aims consolidate the relevant aspects from those two streams of research, integrating their contributions and discussions and bringing them closer together.

To fulfil the gap in literature, this systematic literature review (SLR) identifies strategies and techniques used to increase the megaproject supply chain performance. Additionally, we adopt a multilayer perspective to better understand its impacts on the whole interorganisational network and the interchanges between its permanent and temporary configurations. Usually, megaprojects can be formed of permanent layers of owners and / or sponsors, temporary layers of client organisation / delivery partners (Denicol et al., 2021), as well as varied layers of contractors (Winch, 2014; Davies and Mackenzie, 2014; Davies and Brady, 2016). Therefore, drawing insights from the multi-level nesting arrangement presented by Hitt et al. (2007), the megaproject supply chain can be conceptualised in the levels of organisations and interorganisational networks, as a multilayer structure composed by temporary and permanent organisations. Those levels can refer to the different tiers of the supply chain, for

instance the project owner, the sponsor, the temporary client organisations, and a multiple tier of contractors. This review investigates this multilayer and multi-level configuration of megaprojects to develop a framework of strategies, techniques, and theoretical lenses utilised in the literature to increase the megaproject supply chain performance. Then, the research question of the paper is defined as: “What are the strategies and practices used for performance improvement at the different levels of the megaproject supply chains and what are their impacts across the interorganisational network?”

This paper is organised as follows: In the next section, the research method is presented with a deeper explanation on how the SLR was conducted. Section 3 presents the data structure created to analyse the literature. Section 4 reports the results of the SLR, discussing the main strategies in practices found in the literature. Next, a framework that summarises in a structured form those strategies and practices is proposed in section 5. Finally, section 6 presents the concluding remarks and the suggested research agenda for future studies.

2. Research Method

2.1. The Systematic Literature Review Process

A systematic review allows the reviewer to find relevant information from a growing volume of publications that might be either similar or conflicting (Seuring and Gold, 2012). Research made from a series of relevant studies are more appropriate than those made from a limited set of studies, as it provides in clear method an overall view of the literature, taking into account a vast range of findings around a research topic (Morandi and Camargo, 2015; Akobeng, 2005). The SLR was conducted in three stages as suggested by Denyer & Tranfield (2009) and Tranfield (2003) and being similar to what is recommended by Smith et al. (2011) as well. The first stage starts with the creation of the search protocol, which describes the research question, the terms (or keywords) to be used, inclusion and exclusion criteria, and the databases used for the search (see Appendix A). The second stage comprises the search of the papers and their analysis, comprising the creation of the codes and categories, and the content analysis, providing a general picture of the subject of research. In the last stage, the findings from the literature exploration are reported and discussed.

During the first stage special attention was given to the definition of terms used to conduct the search and their synonyms. Given the vast terminology of megaprojects and supply chains, which extends to management, operations, organisation and project studies, two main terms were used for guidance ("megaproject" AND "supply chain"). From those, classes of terms were created, such as "large" instead of "mega" and "network" instead of "supply chain", and then those were derived into a series of synonyms – e.g., "large scale project" or "large scale program". The terms were defined based on prior knowledge and then validated and agreed upon among the authors. This process resulted in an extensive list, consisting of 10 different classes and 86 synonyms for megaprojects and 4 classes and 19 synonyms for supply chain. To exemplify this, Table 1 is presented below – where we demonstrate only the terms for the supply chain, aiming not be exhaustive.

Term	Class	Class Description	Synonyms
Supply Chain	1	Supply Chain	"Supplier Base", "Supplier Management", "Supplier Network", "Supply Base", "Supply Chain", "Supply Management", "Supply Market", "Supply Network"
Supply Chain	2	Inter / Multi	"Inter-firm", "Inter-organisation", "Multi-firm", "Multi-organisation"
Supply Chain	3	Chain	"Delivery Chain", "Delivery model", "Demand Chain", "Value Chain", "Value System"
Supply Chain	4	Network	"Project network", "Value Network"

Table 1 – Supply chain term example. Source: Original.

With the search protocol and the list of terms defined we proceeded with the search into the databases. The online databases used for the search were Scopus and Web of Science (WOS). We searched for the terms in the abstracts, titles and keywords limited to documents in English only and excluded any type of document that were not articles (e.g., conference papers, books, etc.). A total of 40 sets of search strings were generated from the combination of the classes of both terms (megaprojects and supply chain) which resulted in 1,600

documents from Web of Science and another 1.972 documents from Scopus, totalising 3,572 documents. The search was conducted on 7 December 2020 with no limit regarding the timespan of the publications. Table 2 demonstrates the results from for each set of the search.

Search Set	Term 1 Class	Term 2 Class	WOS Results	Scopus Results	Total
1	Mega / Major	Supply Chain	44	64	108
2	Mega / Major	Inter / Multi	12	18	30
3	Mega / Major	Chain	9	15	24
4	Mega / Major	Network	1	3	4
5	Large	Supply Chain	136	254	390
6	Large	Inter / Multi	28	51	79
7	Large	Chain	25	54	79
8	Large	Network	26	35	61
9	Capital	Supply Chain	25	34	59
10	Capital	Inter / Multi	8	11	19
11	Capital	Chain	9	11	20
12	Capital	Network	14	18	32
13	Complex	Supply Chain	249	284	533
14	Complex	Inter / Multi	61	85	146
15	Complex	Chain	65	68	133
16	Complex	Network	9	9	18
17	Macro	Supply Chain	3	4	7
18	Macro	Inter / Multi	3	6	9
19	Macro	Chain	2	1	3
20	Macro	Network	0	0	0
21	Tera / Giant	Supply Chain	0	0	0
22	Tera / Giant	Inter / Multi	0	0	0
23	Tera / Giant	Chain	0	0	0
24	Tera / Giant	Network	0	0	0
25	Infrastructure	Supply Chain	68	72	140
26	Infrastructure	Inter / Multi	14	16	30
27	Infrastructure	Chain	18	19	37
28	Infrastructure	Network	3	4	7
29	System / project	Supply Chain	23	38	61
30	System / project	Inter / Multi	3	5	8
31	System / project	Chain	6	10	16
32	System / project	Network	8	8	16
33	Temporary	Supply Chain	213	240	453
34	Temporary	Inter / Multi	63	87	150
35	Temporary	Chain	52	60	112
36	Temporary	Network	29	24	53
37	Approach	Supply Chain	347	340	687
38	Approach	Inter / Multi	3	6	9
39	Approach	Chain	15	11	26
40	Approach	Network	6	7	13
Total			**1,600**	**1,972**	**3,572**

Table 2 – Document results by terms. Source: Original.

All the documents resulted from the search were consolidated in Mendeley to exclude the duplicates. A total of 1,362 duplicates were found and excluded, remaining 2,210 documents for analysis of the titles and abstracts. For the analysis of the abstracts, we included all the papers that would refer in some aspect to megaprojects and supply chain. The selection of the articles was discussed among the authors to reach consensus. In some cases, where it was not clear from the abstract and title if the paper was indeed referring to

megaprojects – such as mentioning “large capital projects” – they were included to be analysed during the full reading of the papers and excluded later if found to be not relevant. Then, from the 2,210 papers titles and abstracts analysed, 1,999 were excluded for not meeting the inclusion criteria, resulting in 107 papers to be read in full. From those, other 13 papers were found to be not relevant to the context (from the abstract it seemed that they would be related to mega, large, or complex projects, however, from the main text analysis it was found that they were not) and were excluded, resulting in a total of 94 papers included in this review. Figure 1 presents a diagram demonstrating the SLR process applied in the research.

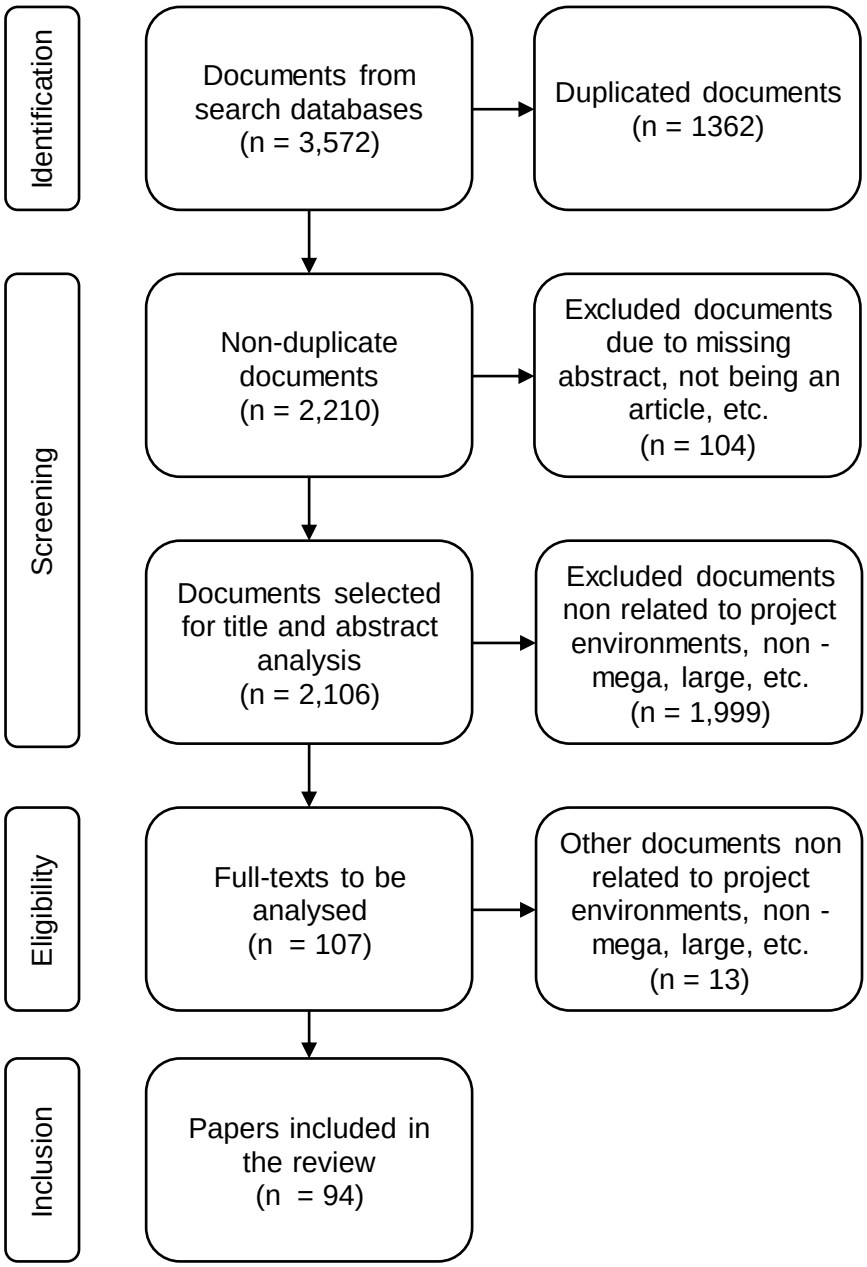


Figure 1 - SLR diagram. Source: Original.

2.2. Coding Method

In order to identify some of the key aspects from our sample, we created several elements to classify the literature. Other than a few basic categories as research objectives, findings, research methods, journal, and country we created our categories of analysis utilising an inductive category building approach. Therefore, our analytical categories were derived from the data and were constantly revised and refined, creating a solid theoretical grounding while being open to new findings (Seuring and Gold, 2012; Eisenhardt, 1989). Thus, we first created the category of theoretical lenses which aimed to identify the main

theories related to the megaproject supply chains context. Then, the main areas of knowledge aim to identify significant clusters of knowledge that form the background of the literature. The strategies – formed in a two-level category (main and sub) which also corresponds to their interfaces – are the focus of this paper and provide the main pillars to improve Megaproject supply chain performance, according to our analysis. Finally, we create the 'level' category represent by the intra-organisational, inter-organisational, and macro-organisational dimensions which also serve as a base to the understanding of the micro, meso, and macro levels of the analysis. Those categories are all presented in detail in the next section.

3. Data Structure

3.1. Theoretical Lenses and Areas of Knowledge

Our first step of the analysis was to identify the main theoretical lenses found on the sample of the 94 papers included in the review. Using an open coding scheme, we identified theories mentioned by the authors in their studies. For this, we maintained a strict procedure to only code theories that were clearly mentioned and/or stated by the authors in their papers in order to avoid any misconceptions or inconsistencies. Also, for papers that claim to use multiple theoretical lenses, we aimed to determine the most predominant one and classify the paper as such. Table 3 below presents the theoretical lenses based on the literature analysis.

Theory	Papers	%
Not clearly stated	47	50,00%
Fuzzy set theory	6	6,38%
Network Theory	6	6,38%
Organisational Theory	5	5,32%
Transaction Cost Economics	4	4,26%
Game Theory	4	4,26%
Institutional Theory	2	2,13%
Contingency Theory	2	2,13%
Complex & Systems Theory	2	2,13%
Other Theories	16	17,02%
Total	**94**	**100%**

Table 3 – Theoretical Lenses. Source: Original.

From the data presented, it is possible to note that most of the papers (50%) do not clearly state the theories in which they are based upon.

Interestingly, this is supported by and aligned with Carter and Easton's (2011) findings from a sustainable supply chain management perspective, where 55% of the papers in their study did not employ any sort of theory. This points out for an still unconsolidated theoretical basis for both SCM and project management domains, which often draw its concepts from different research fields, such as operations research, general management and organisation studies (Thomé et al., 2016). It is also possible to note that generally the theoretical backgrounds are varied and scattered, although some 'clusters' of theories could be identified. Fuzzy set theory, network theory, game theory, and complex & systems theory can all be related to a cluster of complex systems. Meanwhile, transaction cost economics, institutional, and contingency theories can usually be related to project governance aspects (Musawir et al., 2020). However, it is not the aim of this paper to identify and define in-depth and explore the rationale of potential theoretical clusters. In the 'Other Theories' dimensions, we included all theories that were coded only once. This includes, but it is not limited to, resource dependence theory (Zhang et al., 2020), social exchange theory (Wang et al., 2019), and expected utility theory (Qazi et al., 2016).

As demonstrated, from a theoretical lens perspective, it is difficult to provide a reasonable picture of the literature of studies addressing supply chain management in megaprojects. Our findings suggest that many of the papers present their research backgrounds and contributions based on areas of knowledge rather than theories. Those areas of knowledge can be specific, such as innovation in construction (Harty, 2005) or procurement (Brahm and Tarziján, 2015), but overall they converge to wider areas, forming the areas of knowledge category. Once again, using an open coding scheme we identified the papers contributing primarily to one main area of knowledge. This categorisation is qualitative and based on the literature background of each paper, context of the research, and intended contributions claimed by the authors. The areas of knowledge are then presented in Table 4.

Main Area	Papers	%
Project Management	43	45,74%
Operations Management	43	45,74%
Computer Science, Simulation & Optimisation	5	5,32%
Decision Sciences	3	3,19%
Grand Total	**94**	**100%**

Table 4 – Areas of Knowledge. Source: Original.

From the data above, it can be seen that more than 90% of the papers either refer to the project management (PM) or operations management (OM) areas. The computer science, simulation & optimisation dimension represent technical papers that focus on creating or evolving computational models and do not primarily relate to operations or project management literature. Examples of such papers are Du et al. (2020), which proposes a agent-based model to support decision-making in prefabricated component supply chains, and Teizer (2015) that explores vision-based sensing and tracking applications for construction sites. Similarly, decision sciences comprise of papers that rather than computational models focus more on the understanding of decision-making and its theories and also do not relate to OM or PM directly, such as Shi et al. (2018). Those two dimensions represent only 8,51% of our sample and therefore are not the focus of our analysis. Then, it is possible to say that both OM and PM are the most predominant areas of knowledge within the context of the management of supply chains in megaprojects. Although they are the main areas concerned with the subject, the concepts vary within themselves and between each other, using different terminologies and independent perspectives to the same subject (Ahola, 2018; Thomé et al., 2016; Gosling and Naim, 2009). Thus, it is our intent to provide a study that bring those two areas closer together, unifying these the streams of research.

3.2. Supply Chain Strategies, Interfaces, and Levels

Utilising the coding strategy described before, the literature was clustered to identify within the literature the main strategies for performance improvement in the management of megaproject supply chains. The clustering exercise followed a two-level structure comprising a category and sub-category, its details

can be seen in Appendix B. After the analysis of the data, the resulting structure is presented in Table 5 for the categories and sub-categories of the strategies.

Inter-firm Coordination & Collaboration	**Governance**
Coordination and Collaboration Mechanisms	Governance Approaches
Project Trust	Governance Mechanisms
Social aspects, Communication, and Mechanisms	Project Control, Measurement and Decision Support
Supplier Development, Integration, and Management	Project Structure
Procurement	**Projects as Networks**
Bidding, Supplier Selection, & Procurement Systems	Network Structures
Contracts	Project Complexity
Project Alliancing	Supply Networks
Sustainable, Social, and Green Procurement	Temporary Networks
Production and Logistics Strategies	**Risk Management**
Inventory and Materials Management	Project Risks
Production Strategies	Supply Chain Risks
Third-Party Logistics (TPL)	

Table 5 - Categories and Sub-categories. Source: Original.

Initially, the articles were classified in accordance with the most predominant category and subcategory present on the paper. The respective number of papers and their main categories can be found in Table 6. It is important to note that this represents an overall and primary classification and that the relationships among categories and subcategories, content of the papers, and the coding structure is significantly more complex than that. Therefore, we also coded the key points of each paper to a category and subcategory – meaning that one paper can have multiple nodes of code for the same category/subcategory. Also, the papers can, at the same code (or node) and at the same time, refer to more than one category. To deal with that and represent this behaviour, we also mapped the interfaces between the categories – which draws upon the extensive coding process at node level. This means that one paper can also have one category as the primary dimension (as a function of the majority of nodes being coded to that category), but also link with another category (mapped by the interfaces), i.e., procurement and governance. The same rationale applies to the subcategory level (see Appendix B). More details and analysis of these relationships are presented later on this paper.

Category	Papers	%
Inter-firm Coordination & Collaboration	31	32,98%
Governance	25	26,60%
Procurement	11	11,70%
Projects as Networks	10	10,64%
Production & Logistics Strategies	10	10,64%
Risk Management	7	7,45%
Grand Total	**94**	**100,00%**

Table 6 – SLR Categories. Source: Original.

The data shows that inter-firm coordination & collaboration and governance are the most present categories in the literature, which combined represent more than 60% of the total. Then, procurement, production & logistics, networks, and risk management sum up to represent almost 40% of the overall articles. It is important to note tough that this classification is made at document-level representing the most predominant aspect of the paper. To further detail our analysis we coded all the relevant passages of the articles creating the nodes which represent themes or ideas of the papers. Therefore, papers will have only one main category coded at document-level and several interfaces coded at node-level (please refer to Appendix B for clarification). All these categories are discussed in detail in the discussion section.

From the perspective of a multi-layer and nested level arrangement and based on our review, a dimension to represent the level of analysis is created. We propose three dimensions for the category: intra-, inter-, and macro-organisational which can respectively relate to the micro, meso, and macro levels of analysis. Thus, we define as our unit of analysis as the megaproject supply chain, in which: a) at the micro level is concerned with the intra-organisational relations of the individual firms and organisations that compose the megaproject; b) at the meso level focus on the dyadic and extended inter-organisational relationships of the supply chain, considering clients, owners, contractors, etc.; and c) the macro-environment of the supply chain which extend the analysis to social and political stakeholders, relationships of permanent layers of agents not directly inserted in the temporary megaproject organisation, and industry-wide aspects. To present the connections and relationships among categories, interfaces and levels, a Sankey diagram is created and presented in Figure 2.

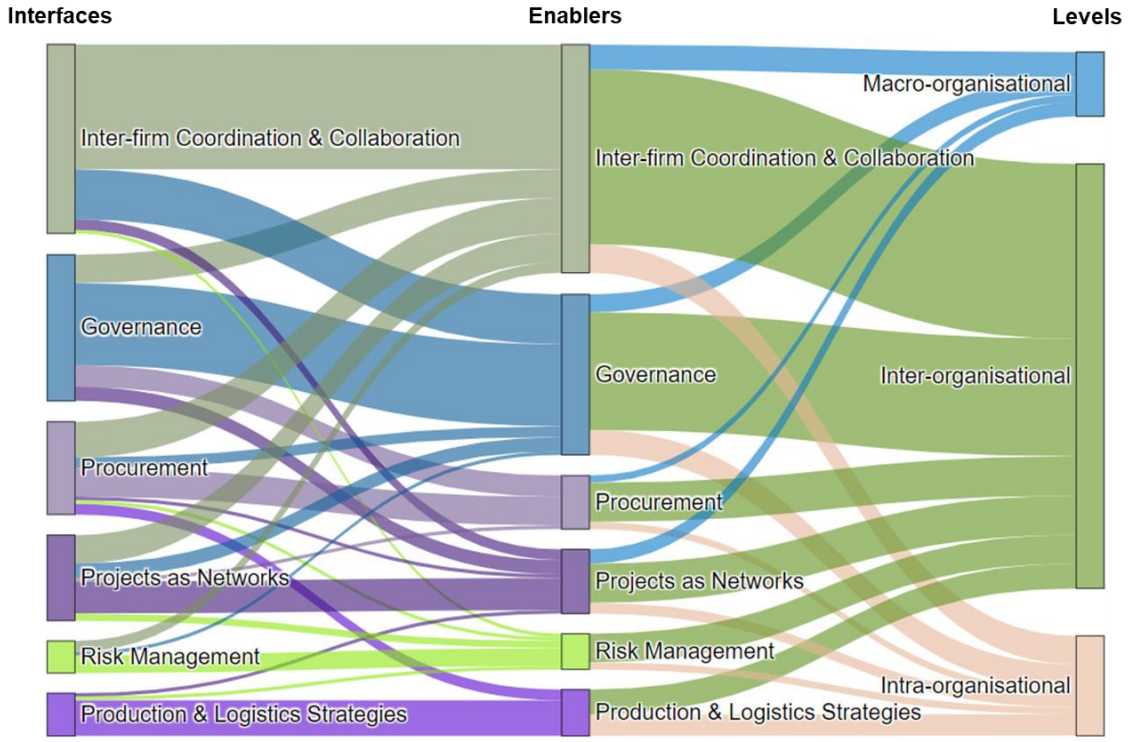


Figure 2 – Sankey Diagram: Categories, Interfaces, and Levels. Source: Original.

In the diagram above, the size of the flows linking one category to another represent the quantity of nodes found connecting those categories. This quantification – as well as the others that will follow – does not aim to be deterministic, but rather it aims to provide a visual representation of the connections and their convoluted behaviour across different topics and levels of analysis. Thus, for inter-firm coordination and collaboration category, it can be seen that about half of the nodes remain within the own category – hence the link with inter-firm – but it also has an interface with governance, procurement, risk management and projects as networks. From the level of analysis perspective, most inter-firm nodes refer to the inter-organisational level, but some representation of macro- and intra-organisational levels can also be found. It should also be noted that some categories seem to be more deterministic and therefore remain confined into its own with little connection to other dimensions, such as production & logistics strategies and risk management. The diagram provides a good overview of the different strategies, its interfaces, and the level of analysis found in the literature. Given the context and theoretical background of supply chain management, the inter-organisational aspects are predominant, but insights for intra- and macro-organisational levels – and potentially multi-level

perspectives as well – can also be found. The next section the discussion presents the results, detailing further the analysis of the findings.

4. Results

In the results section, we will detail each one the categories, as well as their subcategories and interfaces. Several insights are draw from the analysis of the literature and we discuss the strategies for supply chain management in megaprojects, the outcomes, improvements, risk, challenges, and avenues of research. Then, to summarise our key-points, in the following section, we provide a framework that provides an overall picture of the strategies to improve the performance of megaproject supply chains, bringing up relevant aspects of discussion for future research.

4.1. Inter-firm Coordination and Collaboration

Inter-firm coordination and collaboration concern studies that can look at macro environment or individual organisations aspects, but mostly are focused on the inter-organisational relationships among the firms of large-infrastructure projects. Many studies in this category also explore elements of procurement, governance, networks, and risk management. Four main subcategories of inter-firm coordination and collaboration were found based on the literature analysis and are presented in

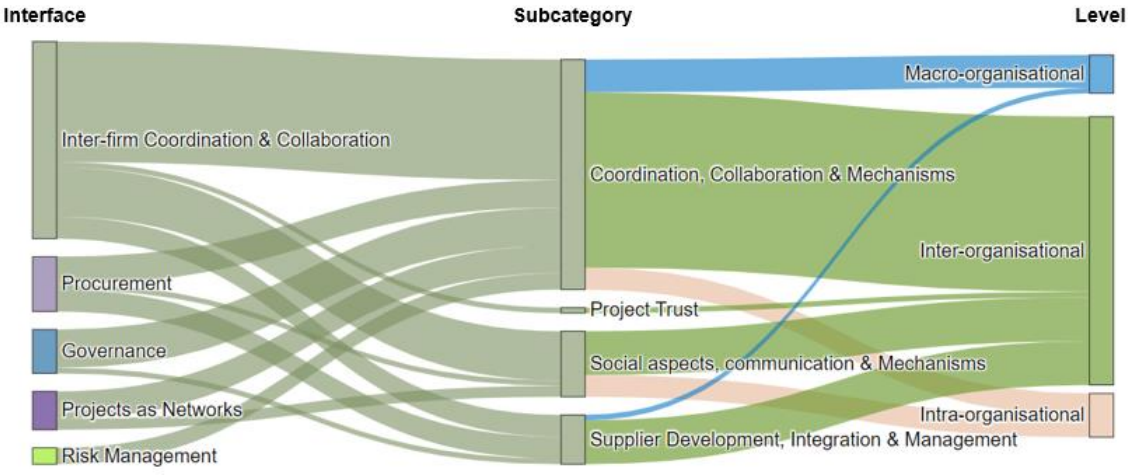


Figure 3, which uses the same structure as the previous Sankey diagram. Those subcategories are: coordination, collaboration, and mechanisms; project trust; social aspects, communications, and its mechanisms; and supplier development, integration, and management.

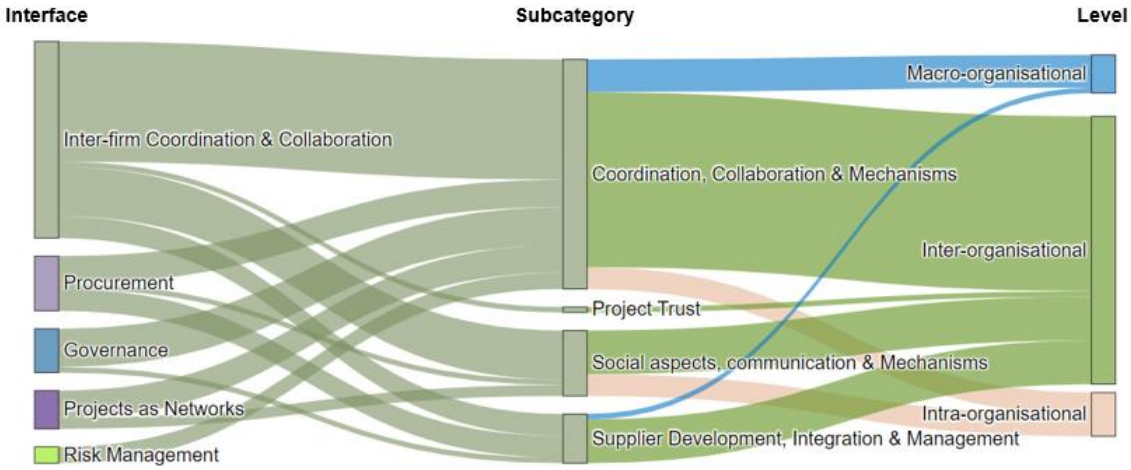


Figure 3 – Inter-firm Coordination & Collaboration: Interfaces, Subcategories and Levels. Source: Original.

4.1.1. Coordination and Collaboration Mechanisms

Mechanisms for coordination and collaboration of firms are basic elements in the structures of organisations which combine both formal and informal elements (Fernandes et al., 2018). Formal mechanisms are related to plans, routines, and processes while informal mechanisms emerge from people within the organisations in a non-planned and non-institutionalised manner (Chakkol et al., 2018; Fernandes et al., 2018). Riazi et al. (2019) mention a few examples of mechanisms for inter-firm coordination: joint agreed goals, supplier pre-qualification, early involvement of all supply chain, profit sharing, among others.

Shi et al. (2018) allude to procurement related aspects affirming that cooperation between suppliers is directly correlated to order quantity, prices, and incentives. Procurement contracts also can be related to coordination and collaboration, Lavikka et al. (2015) compare multi-party and dyadic contracts to coordinate collaboration in complex construction projects. They found that multi-party contracts enable aligned information and knowledge between project parties with the support of other mechanisms such as joint financial incentive, shared project goals, common definitions, and collaborative decision-making. Such mechanisms can also draw a governance perspective, combining elements of governance mechanisms. Chakkol et al. (2018), for instance, discuss the implementation of standards for collaboration – such as the British Standard BS 11000 and ISO 44001 – stating that they can serve as a guide to complement the use of contractual and relational governance mechanisms. Some Authors also use the perspective of temporary project networks to study mechanisms for

coordination and collaboration. Artto and Turkulainen (Artto and Turkulainen, 2018), from an intra-organisation perspective, elaborate on the volume-variety matrix and point out the importance of standardisation of standard design across projects by reusing the organisational subsystem components (i.e. of the same supplier) to foster collaboration. Still from a temporary organisation perspective, Fernandes et al (2018) mention that mechanisms are dynamic over time, also existing simultaneously and to varying extends, i.e. enduring and temporary, centralised and decentralised.

Overall, mechanisms for collaboration and coordination can enable improvement of project performance, achieving better communication, integration and coordination of suppliers within the megaproject (Riazi et al., 2019). Although it is centred in the inter-firm relationship level of analysis it can also extend to macro- and intra-organisational levels. From a macro perspective it can involve mechanisms to collaborate with public bodies or governments (Fernandes et al., 2018; Zhu et al., 2018). In the intra-level perspective, Costa et al. (2019), for instance, discuss the organisational barriers that are completely under the control of the company that can be addressed to improve collaboration.

4.1.2. Project Trust

Although only one paper was found to be primarily related to project trust, this dimension can be found more frequently as an interface with other dimensions such as governance or other subcategories of inter-firm collaboration. The article from Pinto et al. (2009) is the one centred on project trust. It states that project trust enhances a variety of intra-organisational relationships such as project team dynamics, management support, and cross-departmental coordination. At the same time, the authors find that trust is likely to improve inter-organisational relationships among contractors, owners, and suppliers. Similarly, Jost et al. (2005) study cooperation among stakeholders in a public-private partnership (PPP) and set out trust as an underlying fundament of constructive collaboration. They argue that trust should be the core objective in the management of relationships in a PPP environment.

Project trust can also be found as a key aspect from studies with a focus on governance and procurement. Wang et al. (2019) discuss the impacts of

project control and trust in megaprojects and state that the higher the level of trust is, the greater the chance of reciprocity, negotiation, and information sharing between firms. They also argue that trust and control are complementary and positively affect megaproject success, but between the two, trust can be more effective than control. Thus, trust can appear and be relevant both in intra- and inter-organisational and in fact inter-organisational trust is dependent on intra-organisational decisions and practices (Szentes, 2018). Overall, project trust is necessary to achieve integration and coordination in the supply chain, but it is not the only sufficient factor for successful project delivery (Jagtap and Kamble, 2019).

4.1.3. Social Aspects, Communication, and Mechanisms

Socialisation and communication play a key role in inter-firm coordination and collaboration. Similar to the mechanisms for collaboration and coordination, mechanisms for socialisation and communication are varied and often discussed in the literature. Tóth et al. (2018) mention, for instance, planning tools and objects to support the management of network activities and goals, information brokers to control communication flows, and social activities to reduce tensions in teams and inter-firm relationships. Other social aspects, such as commitment, management communication, and relationship-oriented management can be related to intra-levels of analysis and provide important outcomes to project managers and their own teams as well (Klijn et al., 2008).

Other than its relation to collaboration and coordination mechanisms, this dimension also shows interfaces with networks and procurement. Drawing on concepts of social networks, Pauget and Wald (2013) explored relational competence in a project environment. They see relational competence as a requirement for the effective and efficient functioning of networks which is translated as the ability of the network to build and develop collaborative relationships. Similarly, according to Aaltonen and Turkulainen (2018) relational capital can be developed through formal and informal mechanisms. In a project alliance, informal mechanisms help to develop personal relationships and mutual trust and were associated with higher levels of relational capital, while formal socialisation mechanisms were used to maintain the current level of relational capital.

4.1.4. Supplier Development, Integration, and Management

Naturally, this dimension is focused on the inter-organisational relationships and has a significant interface with procurement, given its concern with supplier selection as seen in Tchokogué et al. (2017) or Zeng et al. (2019). Supplier development and management aims to organise information, processes, teams, and companies to develop further collaboration and integration within the megaproject supply chain. The selection of suppliers and the types of partnerships (collaborative and/or relational-oriented) to be developed with them are critical for defining the appropriate supply management strategy for the project. Strong relationships with suppliers can help overcome uncertainties in supply management activities of complex projects (Tchokogué et al., 2017).

The mechanisms for supplier development and integration are varied. Hall et al. (2018), for instance, mention 9 different mechanisms: local owner representation, fiscal transparency, BIM coordination, project team colocation, multiparty incentivized contracts, early involvement of key participants, interfirm project board, TVD, and lean construction principles. Zeng et al. (2019) discuss incentive mechanisms for the development of suppliers and focus on three main components: cost sharing, purchase price, and purchase quantity, similar to the proposition of Shi et al.(2018) regarding collaboration mechanisms. The authors, however, have a different perspective which focus on the improvement of quality instead of cooperation among suppliers. According to them, cost sharing for investment in quality improvement is the most impactful of the three as the suppliers can benefit from investment reduction and take competitive advantages in future markets.

A connection with governance is found on the paper from Martinsuo and Ahola (2010), which compares supplier integration from a project control perspective with more cooperation-oriented practice. Supplier development and integration can also involve macro aspects in complex environments such as the Olympic Games (OG) as there are many ‘external’ actors – such as the OG organising committee and international federations – that can influence supplier selection (Tchokogué et al., 2017).

4.2. Governance

Most project governance research are concerned with inter-firm governance mechanisms implemented in megaprojects. However, it also includes insights related to project control and structure as well as discussion of whole governance systems – i.e., governance approaches. Figure 4 depicts and summarises the nodes coded with the governance dimension with the following subcategories: project control; governance mechanisms; project structure; and governance approaches.

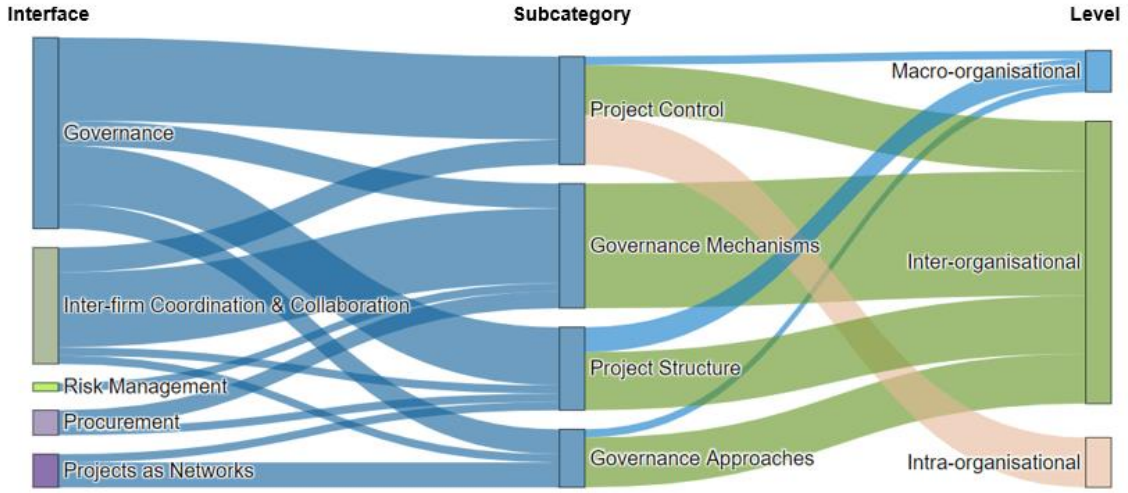


Figure 4 – Governance: Interfaces, Subcategories and Levels. Source: Original.

4.2.1. Governance Mechanisms

As already mentioned, governance mechanisms have a significant interface with collaboration and coordination mechanisms, but often expanding beyond those concepts. Kujala et al.(2020), for instance, consider coordination as a dimension of interorganisational governance. They cite numerous examples of governance mechanism across six governance dimensions, including: formal control and monitoring; informal monitoring; rewarding tied to performance; risk allocation; common project management practices; shared culture, values, and norms; communication and information sharing; among others.

Another perspective on mechanisms, which interfaces with procurement, comes from Jagtap and Kamble (2019) which discuss the procurement specific factors (PSFs) associated to the relational governance of the project. They define PSFs as countermeasures in the form of mediated power, non-mediated power and the assessment of project risk used to deal with the contextual factors of

project procurement. They found the PSFs and the party types (client or contractor) to be significant mediators impacting the governance of supply chain, concluding that client- and contractor-led initiatives affect the project SC. Hetemi et al. (2020) points out the importance of the understanding of the long-term inter-organisational perspective with regards to governance mechanisms and its effects – rather than decisions made at individual level – to avoid the emergence of lock-in situations.

Overall, governance mechanisms can reduce opportunistic behaviours, increase awareness of project risk (Jagtap and Kamble, 2015), help deal with project changes (Hetemi et al., 2020), foster cross-disciplinary cooperation and innovation, promote self-monitoring, alignment of goals, and support knowledge integration (Kujala et al., 2020), among other benefits.

4.2.2. Project Control, Measurement and Decision-making Support

Studies in project control are varied and include, for example, the understanding of the relationships between control and commitment (Van Marrewijk, 2005), methods for measuring project performance (Chen, 2015), and the design control systems (Boland Jr. et al., 2008). It can focus either on intra- and inter-organisational levels, consisting of different types of mechanisms divided in financial, bureaucratic, and socialisation modes (Van Marrewijk, 2005). It builds a formal process that managers use to influence other towards achieving a goal (Wang et al., 2019).

Project control can be related to collaboration regarding inter-firm project trust and social exchange norms such as reciprocity, negotiation, and the sharing information between organisations of the project supply chain (Wang et al., 2019). Models to support decision-making, often include performance measurement aspects such as projects costs and budget, as seen in Wood (2017) and Steen et al. (2017). Overall, control is found to have a positive impact on megaproject success (Wang et al., 2019). Similarly, project performance measurement – including allocation of budgets, scheduling, progress capture, and baseline data – can improve performance and productivity of the supply chain (Wickramatillake et al., 2007).

4.2.3. Project Structure

Studies of this subcategory aim to understand the overall structure arrangement and organisation of firms, actors, and other diverse entities in the megaproject environment. Topics of discussion within project structure include, but are not limited to, the centralisation and decentralisation of control and decision-making (Bouraoui and Lizarralde, 2013; Genus, 1997a), the role of the client within the project (Brady, 2011), and the intra relationships of direction and empowerment against inter-organisational control and flexibility (Szentes, 2018).

From a macro-organisational perspective, Toor and Ogunlana (2008) observes general project structure issues causing delays in the construction industry in Thailand. Eren (2019) takes into consideration diverse political and social aspects going around the construction of Istanbul's airport and observes that a government-level organisational structure reduced complexity, risk, and uncertainty and improved interorganisational compatibility and communication. Bouraoui and Lizarralde (2013) adds end-user participation and concerns and depicts the temporary project structure of Tunisia's case in a post-disaster reconstruction project. They found that the decentralised decision-making structure used in the project optimised the efficiency of local stakeholders, facilitated the involvement of end-users, and allowed an appropriate distribution of responsibilities and risks across the stakeholders.

4.2.4. Governance Approaches

Unlike governance mechanisms, governance approaches refer to a broader sense in which whole systems of governance are studied rather than specific mechanisms. According to Bekker (2014) project governance definition varies in accordance to their technical level of controlling, monitoring and complying and the institutional level of guidance, decision and responsible citizenship. Additionally, governance approaches differences are more influenced by stakeholder complexity than by project complexity, as they usually involve governing the internal supply chain composed by multiple, multinational firms and, at the same time, an external network of actors affected by the megaproject.

Notably, Ruuska et al. (2011) propose a new governance approach as an alternative to the traditional hierarchical view of project governance. According to

the authors it can be misleading to think that a large multi-organisational project can be governed by activity systems of one or a few parties of the network. Thus, drawing insights from the project network view they propose an open systems approach to governance in which projects are embedded and interwoven with complex institutional environments. In their approach, they also add considerations regarding a view of supply networks instead of the hierarchical supply chain, a shift of coordination mechanisms based on simplistic perspectives such as price to mechanisms more focused on relationships and self-regulation, and finally, the extension of the multi-firm temporary view of projects to an extended view that includes business interests of the actors beyond the project's duration.

Von Danwitz (2018) also proposes a governance model that can be used as a guideline to holistically design governance regimes, indicating context and design elements to take into consideration when creating governance processes and structures. He proposes a model that bases project governance according to seven dimensions divided between structures and processes and other eight contextual dimensions dived into project specific characteristics and characteristics related to the relationships between project partners. According to the author, governance approaches have a significant effect on project performance in terms of time, budget, and quality.

4.3. Procurement

Within this category, the procurement processes and the inter-firm relationships are explored through practices such as contracts and project alliancing. Sustainable and green procurement presents an interesting discussion that goes beyond the inter-firm of procurement processes. Lastly, some insights can be drawn regarding supplier selection and procurement systems. Figure 5 presents the Sankey diagram for procurement, with the following sub-categories: sustainable, social, and green procurement; contracts; project alliancing; and bidding, supplier selection, and systems

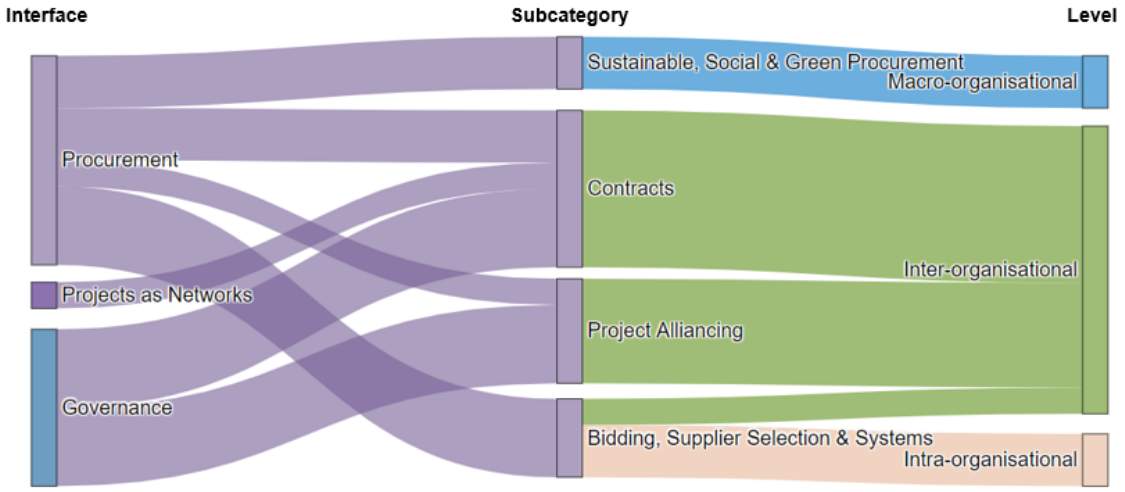


Figure 5 – Procurement: Interfaces, Categories, and Levels. Source: Original.

4.3.1. Contracts

The literature on contracts usually will explore the different types of contracts, comparing them, and describing the benefits and risks of each type. Contracts have an interface with governance as some types of contracts can impact the structure of the project in general. Genus (1997b) uses the case of the channel tunnel to describe the design and build type of contract adopted at the project and the problems and issues faced by that. According to the author, the type of this construction contract caused problems by increasing the diverging interests of the client and the contractor, expressed by distinct views regarding project specifications and the monitoring and pricing of the work concluded. Eventually, this situation combined with the non-existing and/or weak client in the initial stages of the project led to goal incongruence and performance ambiguity.

Types of contracting is also explored by Brahm and Tarziján (2015). They make a comparison of a make-or-buy decision – whether 'making' the project internally or 'buying' a contractor to do so –while at the same time exploring fixed-price and cost-plus contracts when using contractors. They find that using a contractor is a better overall solution in complex environments as it creates a consensus-based hierarchy which fosters knowledge sharing, communication, and consensus building. Similarly, contracts can also be an interface of collaboration mechanism as noted by Lavikka et al. (2015). They mention that multi-party contracts aligned information and knowledge flows through the specification of organisational and technological mechanism such as financial

incentives, collaborative decision-making, and BIM. In contrast, dyadic contracts needed complementation during the design phase and additional procedures for coordination of parties.

4.3.2. Project Alliancing

Project alliancing (PA) is an approach that gives emphasis to integration through the early involvement of strategic parties, transparent financials, shared risks and rewards, and collaborative decision-making all being managed by exploiting the integration mode – the organisational and relationships arrangements of the project (Hietajärvi et al., 2017a). It is a relational approach, based on multi-party contracts, promoting strong collaboration and integration between the organisations of the project (Hietajärvi et al., 2017c).

Focused on the inter-firm relations of the project, PA can be a very effective strategy for projects with specifics characteristics such as large investments, high complexity, and a multitude of stakeholders (Young et al., 2018). Both Aaltonen and Turkulainen (2018) and Hietajärvi et al. (2017c) give attention to the importance of relational skills and socialisation in project alliances, which is needed to interact and cooperate inter-organisationally across the project lifecycle. Similarly, according to (Hietajärvi et al., 2017b), PA supports active opportunity management, supporting the creation of a collaborative work culture with an open communication with the client organisation. In the end, PA can provide competitive advantage through close collaboration and integration, knowledge sharing, and the ability to deal with the complex problems faced by large infrastructure projects (Walker and Jacobsson, 2014).

4.3.3. Sustainable, Social & Green Procurement

Green procurement relates to the process where organisations procure services and materials that can meet environmental requirements. Its extension, sustainable procurement, goes beyond the environmental requirements and incorporates social considerations in the procurement process (Uttam and Le Lann Roos, 2015). With a strong correlation with environmental and social aspects, it often can involve governments, regulatory bodies, and communities this dimension is directly linked to the macro-organisational level of analysis.

Unfortunately, only two papers focusing on suitable and social procurement were found. Loosemore (2016) discuss the challenges and changes needed for construction companies to achieve the application of social procurement in the UK. He demonstrates the necessary changes to traditional procurement practices – such as huge work packages and economies of scale – to encourage social enterprise engagement in construction projects, as well as the critical leadership role portrayed by client organisations to promote such changes. Uttam and Le Lann Roos (2015) focus on the competitive dialogue procedure (CDP) to promote sustainable public procurement. According to the authors, CDP can facilitate the involvement of contractors for the preparation of the sustainable related specifications of the contract. They also mention the importance of the contracting party to fully understand the relevant considerations regarding sustainable procurement to be able to have constructive dialogues with the contractors.

4.3.4. Bidding, Supplier Selection, and Procurement Systems

This sub-category refers to the operational aspects of procurement concerning supplier selection and procurement systems. Most studies look at the procurement processes of organisations, while a few pay attention to the inter-organisational and dyadic relationships concerning such procedures. In fact, papers that use this subcategory as their main focus are mostly technical papers related to procurement systems. Procurement systems can be interfaces of collaboration mechanisms in the form of Enterprise Resource Planning (ERP) and similar systems (Kovács et al., 2003), specific systems to support supplier selection, contract management and the bidding process (Safa et al., 2017), and other models to support procurement decision-making (Bugrov and Bugrova, 2018).

However, as previously mentioned, the bidding process and supplier selection are critical for defining the appropriate supply strategy of the project (Tchokogué et al., 2017) and they are more presented in the literature as interfaces that support other main categories. Ruuska et al. (2009), for example, focus on project networks and include bidding processes aspects as quotation information and principles for the selection of suppliers as an important dimension that affects the ‘distance’ between the diverse network agents. Supplier pre-

qualification (Riazi et al., 2019) and incentive mechanisms such as prices and order quantity (Zeng et al., 2019) are also good examples as they are analysed by the literature from the lens of collaboration and coordination, but are intrinsically related to procurement biding processes. Therefore, well-designed bidding and supplier selection processes and robust procurement systems can influence collaboration, coordination, and communication between suppliers (Riazi et al., 2019), support procurement decision-making (Zhang et al., 2018) and enhance efficiency and performance of related parties (Safa et al., 2017).

4.4. Projects as Networks

Project networks draw concepts from complex systems (Kujala et al., 2020) and social networks (Adami and Verschoore, 2018; Pauget and Wald, 2013) to describe behaviours and structures of the multi-organisational environment of megaprojects, its suppliers and stakeholders, and its relationships. Adding to its nature of complexity, it can also consider other varied as aspects such as the temporariness of such endeavours (Pauget and Wald, 2013; Ruuska et al., 2009). Figure 6 depicts the overall analysis of the literature related to project networks and the following subcategories: network structures; temporary networks; supply networks; and project complexity.

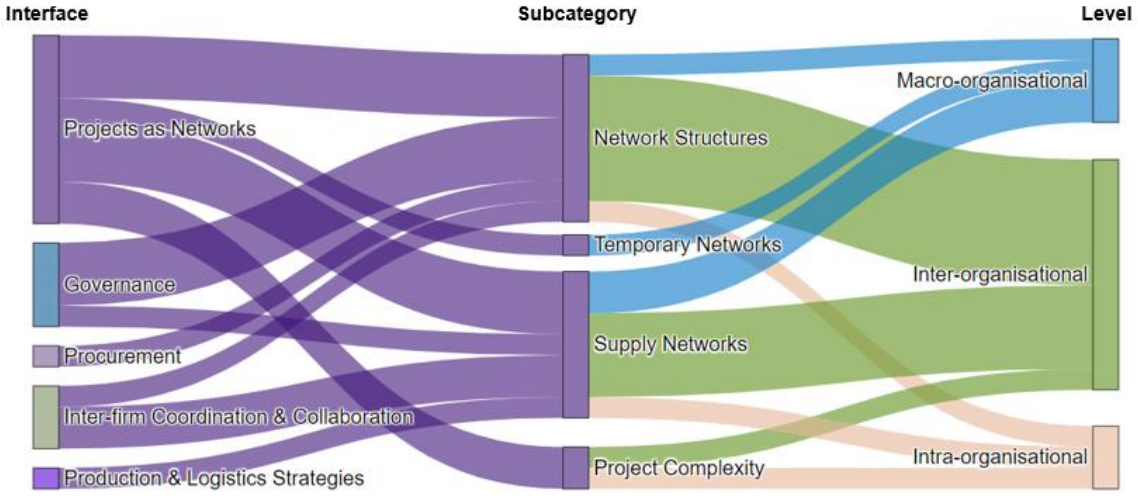


Figure 6 – Projects as Networks: Interfaces, Strategy Subcategories and Levels. Source: Original.

4.4.1. Network Structures

This sub-category is concerned with the understanding of the overall structure of the project network, including measures such as the network size

(number of actors), the connectivity between the actors, or the symmetry of relations between actors (Pauget and Wald, 2013). Network structures provide a holistic view to analyse project networks and how they are managed (Ruuska et al., 2009). Hellgren and Stjernberg (1995) see the network structure as a representation of the project in the form of processes of organising between actors with different, and even conflicting, rationalities towards goals and priorities and in distinct and dynamic power positions in the overall structure.

Network structures can be used to help the understanding of the dynamics of megaprojects – for both individual actors or the whole network – such as complexity levels, governance issues, contractual relationships, and flows of information and goods (Adami and Verschoore, 2018). From a network structure perspective, Ruuska et al. (2009) propose a distance framework, composed of firm attributes (which focus at the intra-organisational level), project practices, and network attributes. According to them, network attributes can describe the distance between the relationships of actors which, similar to what is stated by Hellgren and Stjernberg (1995), include misaligned objectives, unclear roles and responsibilities, lack of trust and diversity of actors. Network structures can also be expanded to macro-level of analysis to include as communities, governments and other external stakeholders (Yang et al., 2018).

4.4.2. Supply Networks

Supply networks differ from the traditional hierarchical models found in the literature mostly in regard to their level of complexity, consisting of several same- and inter-tier suppliers supplying to each other, inter and reserve tier relationships which creates a system with nonlinear dynamics (Brintrup et al., 2017). Such models can provide a better understanding on the overall organisational structure and governance formed by owners, operators, sponsors, clients, and suppliers and how such arrangements impacts the performance of megaprojects (Denicol et al., 2020).

Thürer et al. (2020) present a research on the China's belt road initiative (BRI) supply network and explore four key-aspects around the supply chain: configuration, resilience, sustainability, and cross border supply chain management. Other than the inter-organisational relationships, the authors

explore the macro-level taking into consideration economic, environmental, and political aspects and impacts of the initiative. From a supply network perspective, an interface with production strategies is mentioned by Denicol et al. (2020). They suggest the application and exploration of manufacturing strategies and digital technologies in megaprojects to bridge the productivity gap between construction and other industries. This could open space for intra-level studies focusing on specific organisations inserted in a supply network.

4.4.3. Project Complexity

Project complexity is presented in varied forms in the literature. According to De Rezende et al. (2018), the field of complexity evolved from disconnected works to more current discussions focused on uncertainty and dynamics and supporting managers in adapting and managing complex projects. They include aspects such as complexity models and systems, performance, uncertainty, design, and innovation. Project complexity is seen as significant to megaproject failure, causing cost and time overruns (Qazi et al., 2016).

Still, project complexity was found in the megaproject literature more as a secondary aspect or a characteristic of such endeavours. Edkins et al. (2007), for instance, propose cognitive mapping methodology to better understand complex processes and they influence overall complexity in project management; Qazi et al. (2016) propose a risk management process to capture the interaction of project complexity and risks. Mohagheghi et al. (2020) use project complexity as a dimension for the evaluation of project resilience; and Brahm and Tarziján (2015) analyse how project complexity affects project procurement decisions. In summary, project complexity is an inherent characteristic of large infrastructure projects that needs to be recognised and managed at intra- and inter-organisational levels of the project network (De Rezende et al., 2018).

4.4.4. Temporary Networks

Similar to what was found in project complexity, within the megaproject supply chain literature, temporary networks have received more attention as a background aspect or depicted as a characteristic of large and complex projects. The concept of temporariness embedded in project networks refer to the fact that they exist in that specific structure only during the life-cycle of a single project

(Ruuska et al., 2009). According to van Fenema et al. (2016) the temporary network of megaprojects is a developmental process that occurs across four dimensions: heterogeneous stakeholders, governance, knowledge and coordination routines, and performance management.

Ruuska et al. (2009) challenge the view of projects as temporary endeavours with finite life cycle, claiming for a new perspective where projects are still incorporated in business interests of the actors beyond the lifespan of the project. Nevertheless, temporary networks still provide ground and context for other discussions such as their coordination and its mechanisms (Fernandes et al., 2018), the assembly of project capabilities (Zerjav et al., 2018), and the relationships between its actors and their governance (Pauget and Wald, 2013).

4.5. Production and Logistics Strategies

Production and logistics strategies are focused on intra- and inter-organisational perspectives of the megaproject supply-chain. They focus on processes and practices concerned with productivity issues, cost reduction, and other relevant production and construction site aspects. Figure 7 presents the overall category and its subcategories: third-party logistics (TPL); production strategies; and inventory and materials management.

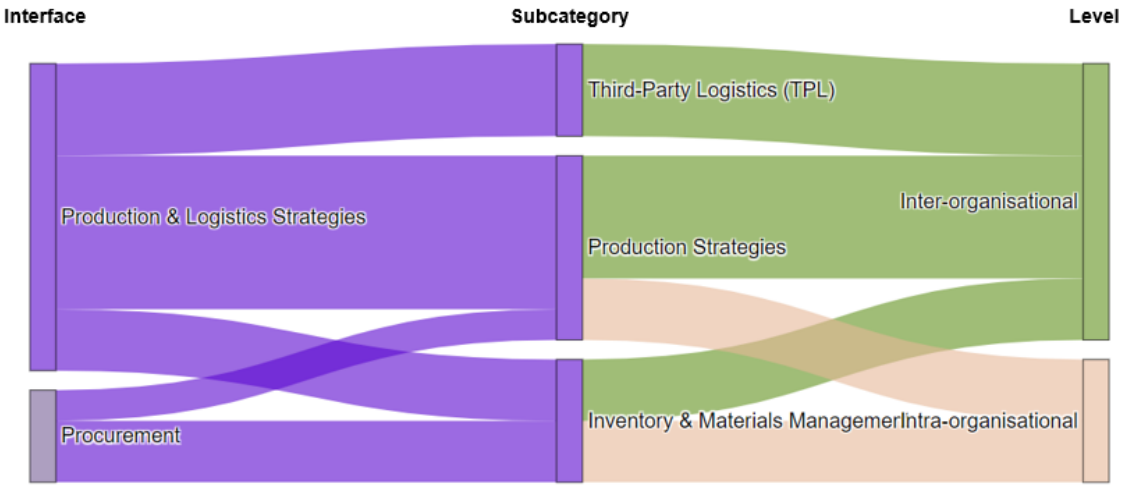


Figure 7 – Production and Logistics Strategies: Interfaces, Subcategories and Levels. Source: Original.

4.5.1. Production Strategies

Production strategies refer to approaches commonly used in manufacturing environments to increase productivity, efficiency, and overall

performance. They include, but are not limited to, just-in-time (JIT) (Walsh et al., 2004), quality management (Wu et al., 2013), and relevant concepts of engineer-to-order, assembly-to-order, and make-to-stock (Denicol et al., 2020). Those strategies tend to either be applied at sole organisations or at project level with key partners or suppliers, thus, they focus on intra- and inter-organisational levels.

These production approaches bring benefits to manufacturing industries and more recently have been discussed in the megaproject supply chain literature, as well. Among its benefits in the large and complex projects, Walsh et al. (2004) uses a simulation model based on a case-study to say that JIT brings savings in up-front capital, reduction of inventory costs, increased flexibility, and consequently an improvement in performance. A concept related to JIT, the lean manufacturing is found in Dainty and Brooke (2004) to discuss strategies of waste mitigation in the construction industry. According to the authors, off-site fabrication and standardisation of design, and alliance with suppliers to remove and recycle materials from construction site are all effective measures to promote lean, waste minimisation, and even cost savings in the construction industry. Denicol et al. (2020) claim that manufacturing production strategies and digital technologies pose as an opportunity to make megaproject delivery more efficient and effective.

In fact, digitalisation allows improvement of manufacturing processes through automation, integration, and the utilisation of AI and smart tools (Cerezo-Narváez et al., 2018), such as the automated tracking and monitoring of construction sites using vision-based sensing (Teizer, 2015). Another form of process improvement – quality management, when applied in large complex projects can also present economic benefits, customer satisfaction, and better coordination of the supply chain (Wu et al., 2013). To Gaudenzi and Qazi (2020) project managers can use quality management standards to adopt audit procedures and quality tools to monitor key processes of the supply chain and improve overall performance.

4.5.2. Third-Party Logistics (TPL)

From a supply chain management perspective, TPL aims to rely on specialised third-party actors to manage logistics and coordinate material flows across the supply chain (Le et al., 2020). The construction industry have paid more attention to third-party logistics as a means to deal with its challenging context, accompanied by higher costs and lower productivity when compared to other industries (Ekeskär and Rudberg, 2016). In fact, regarding TPL the megaproject supply chain literature has mainly focused on the benefits of its application.

Through a case study, Janné and Rudberg (2020) report a series of positive impacts, such as the reduction of disturbances in the site and the supply chain, reduction of in-site materials, better utilisation of site space, higher productivity, and improved supply chain visibility and planning. From another case study complemented by a literature review, Ekeskär and Rudberg (2016) find positive effect in the establishment of an effective interface between the construction site and the supply chain, along with increase in productivity, reduced costs and better utilisation of site assets. Finally, corroborating with the previous findings, Le et al. (2020) create a decision-making model with a possible TPL integration and find that TPL can improve logistics performance, optimise supply chain costs and help with general issues in the construction industry.

4.5.3. Inventory and Materials Management

The materials management goal is to ensure that the right material is procured in the correct quantity, with the required quality, at a reasonable price and available when needed (Caldas et al., 2015). It is accomplish by a set of different approaches as strategic inventory management (Walsh et al., 2004), monitoring and tracking (Nasir et al., 2010), materials requirement planning (MRP) (Caldas et al., 2015), and others.

Effective inventory and materials management can be beneficial for the supply chain. Walsh et al. (2004) suggest the strategic positioning of inventories as an option to owners and contractors, allowing workforce assignment flexibility and eliminating shipment and – as a consequence – construction delays. However, as it requires procurement of materials in advance, it has some trade-

offs regarding inventory costs and up-front capital requirement. Nasir et al. (2010) report increased productivity, reduction of material loss, and reduction of necessary workforce. Overall, inventory and materials management reduce costs, increase productivity, improve quality, enhance reliability, and thus are critical for maximising project performance (Caldas et al., 2015; Nasir et al., 2010).

4.6. Risk Management

Risk management is explored in the megaproject supply chain from the perspectives of the project and of the supply chain. Mostly focused on the inter-organisational aspects, risk management either has an interface or is an interface with all the other categories discussed in this review. Figure 8 presents the summary of the categories and sub-categories of risk management.

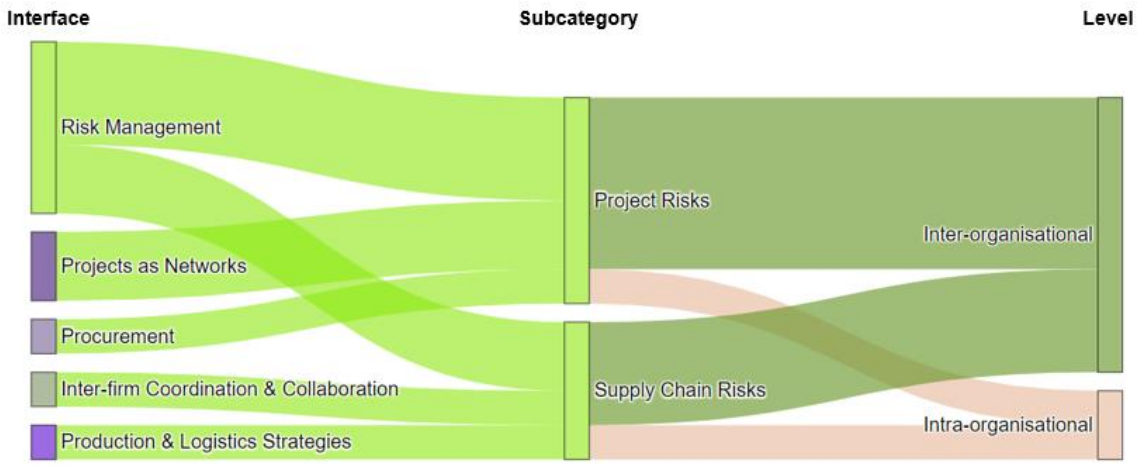


Figure 8 – Risk Management: Interfaces, Strategies Subcategories and Levels. Source: Original.

4.6.1. Project Risks

Project risk consists of relational and performance risks. In the client-contractor dyad, it is longitudinal and dynamic and appears in the operational behaviour of the project. It can be perceived in the shortcomings of project performance, cost, time, quality, procurement mechanisms, and the contractual obligations to deliver the project (Jagtap and Kamble, 2015). Methods to manage project risk are well-documented in the literature in varied models (Qazi et al., 2016) and processes (Hietajärvi et al., 2017b; Riazi et al., 2019).

Project risk management can help identify, monitor (Boateng et al., 2015), and mitigate project risks (Riazi et al., 2019), facilitate tracking and control of

project performance, and be a means for collaboration (Jagtap and Kamble, 2015). An interesting point is that through collaboration and open communication, risk management can give rise to opportunity management – also known as 'positive' risks – which proves to be an important process to support innovation development and delivery in large projects especially in project alliances where collaboration, knowledge sharing and organisational learning are fostered (Hietajärvi et al., 2017b).

4.6.2. Supply Chain Risks

In this dimension risk management is more concerned with the supply chain issues, such as supply chain configuration, logistics, planning and forecasting, and inventory (Rudolf and Spinler, 2018). Like project risk management, it includes models and processes to identify, measure, and mitigate risks related to the supply chain.

Zhao (2019) builds an interactive coordination model for the megaproject supply chain to understand and identify infectious risks throughout the chain and how to cope with them. He states that the earlier the risks are found the lower are the costs and efforts to mitigate them and therefore the identification of risks is beneficial to their own elimination or to mitigate their propagation in the supply chain. Gaudenzi and Qazi (2020) claim that supply chain risk management methods provide a holistic view of interdependent risks and identify them supporting the creation of proactive risk mitigation strategies. Thus, as large projects are inherently exposed to high level risks, robust supply chain risk management must be seen as an essential activity in the management of megaprojects (Rudolf and Spinler, 2018).

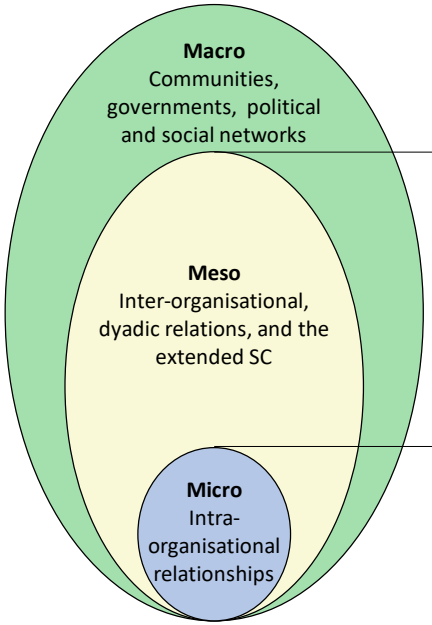
5. Framework Proposition, Implications and Research Agenda

Based on our results and analysis, we present a multi-level megaproject supply chain (MMSC) framework that summarises the current literature on the management of supply chains in megaprojects and propose a research agenda to guide future studies. The proposed framework considers and incorporates many of the theoretical lenses found, reviewed, and categorised during the SLR process, as well as the dynamics of temporary and permanent components of the megaproject supply chain. Thus, based on the framework and the analysis, it is

possible to discuss a few opportunities, risks, and contributions for each one of the categories., which is complemented by the proposal of a research agenda.

5.1. The Proposed Framework

We also define the supply chain as the unit of analysis thus unpacking and defining its micro, meso, and macro levels. At the micro-level the studies are focused on specific organisations, teams, or individuals and boundaries of the study are the organisation itself. Although it can be inserted within a project supply chain, at the micro level less attention is given to inter relationships and connections beyond the focal company, rather looking at specific organisational processes, construction sites, teams, and individuals. Klijn et al. (2008), for example, study how managers of complex public-private partnerships deal with difficult choices and dilemmas in their managerial routines. In another example, Nasir et al.(2010) propose an implementation model for automated materials tracking and location on large and complex projects. At the meso-level the focus shift to the inter-firm relationships including dyads and the extended supply chain. Naturally, most supply chain studies are within this dimension, but there are opportunities to explore the other levels, as seen in many examples discussed previously. The macro-organisational level expands the megaproject supply chain to include external stakeholders (Yang et al., 2018), socio-political aspects (Eren, 2019), industry-wide factors (Yun et al., 2016), and temporary and permanent cluster of actors within a network (Denicol et al., 2020; Pauget and Wald, 2013). Based on that, the framework presents the main strategies and practices found in the literature and connects them to the respective level, as shown in Figure 9. The framework depicts the three nested levels at the left side which cross the six previously defined categories. Then, at each quadrant of category and level, the main strategies and practices for supply chain performance improvement in megaprojects are presented, in accordance with what was found in the literature.



Supply Chain Strategies for Megaprojects					
Inter-firm Collaboration and Cordination	Governance	Procurement	Projects as Networks	Production and Logistics Stragegies	Risk Management
• Collaboration standards (Chakkol et al., 2018)	• Government hands-on management (Eren, 2019) • Decentralised decision making (w/ external stakeholders) (Bouraoui and Lizarralde, 2013) • Benchmarking (Yun et al., 2016)	• Competitive dialogue procedure (CDP) (Uttam and Le Lann Roos, 2015) • Social procurement (Loosemore, 2016)	• Supply chain configuration (Thürer et al., 2020) • Knowledge and coordination routines in temporary organisations (van Fenema et al., 2016)		
• Cost sharing, purchase price, and purchase quantity (Shi et al., 2018; Zeng et al., 2019) • Early involvement of key participants (Hall et al., 2018) • Information sharing (Wang et al., 2019) • Joint agreed goals (Riazi et al., 2019) • Development of relational competence (Pauget and Wald, 2013)	• Alignment of goals (Hetemi et al., 2020; Kujala et al., 2020) • Decentralisation of control and decision making (Genus, 1997a; Van Marrewijk, 2005) • Definition of roles and responsibilities (Kujala et al., 2020) • Monitoring and performance measurement (Kujala et al., 2020; Steen et al., 2017; Wood, 2017) • Open systems view (Ruuska et al., 2011)	• Multi-party contracts (Brahm and Tarziján, 2015) • Cost-plus contracts (Lavikka et al., 2015) • Project alliancing approach (Hietajärvi et al., 2017a; Walker and Jacobsson, 2014; Young et al., 2018)	• Capability mechanisms for temporary settings (Zerjav et al., 2018) • Flows of information and goods (Adami and Verschoore, 2018) • Network attributes undestanding (Hellgren and Stjernberg, 1995; Ruuska et al. 2009) • Network perspective for the supply chain (Brintrup et al., 2017)	• Just-in-time (JIT) / Lean manufacturing (Dainty and Brooke, 2004; Walsh et al., 2004) • Quality management (Gaudenzi and Qazi, 2020; Wu et al., 2013) • TPL implementation (Ekeskär and Rudberg, 2016; Janné and Rudberg, 2020; Le et al., 2020)	• Risk management modeling (Qazi et al., 2016; Zhao, 2019) • Risk management processes (Hietajärvi et al., 2017b; Riazi et al., 2019; Rudolf and Spinler, 2018)
• Management support (Pinto et al., 2009) • Relationship-oriented management (Klijn et al., 2008) • Reutilisation of subsystem components (Artto and Turkulainen, 2018)	• Control systems (Boland Jr. et al., 2008) • Critical path optimisation and measurement (Elizabeth and Sujatha, 2015, 2013; Wood, 2017)	• Robust supplier selection processes (Riazi et al., 2019; Tchokogué et al., 2017) • Procurement systems (Kovács et al., 2003; Safa et al., 2017)	• Cognitive mapping (Edkins et al., 2007)	• Digitalisation (of processes) (Cerezo-Narváez et al., 2018; Teizer, 2015) • Monitoring and tracking of materials (Nasir et al., 2010) • Materials requirement planning (MRP) (Caldas et al., 2015)	• Opportunity management (Hietajärvi et al., 2017b)

Figure 9 – The Multi-level Megaproject Supply Chain (MMSC) Framework. Source: original.

Based on the framework and the detailed analysis provided in the results section, some interesting implications, both practical and theoretical, can be discussed using the micro-, meso-, and macro-level perspectives. First, it is possible to denote a strong interconnectedness among inter-firm collaboration and coordination, procurement, and governance. Many mechanisms of governance such as alignment of goals (Hetemi et al., 2020) and decentralisation of decision-making (Bouraoui and Lizarralde, 2013) aim for better collaboration and coordination (Kujala et al., 2020) among actors of the supply chain. Meanwhile, mechanisms of collaboration and coordination such as joint agreed goals and information sharing may compose – and be one objective of – whole systems of governance. Such relationships make it even harder to distinguish governance mechanisms from collaboration mechanisms, as they usually work – and should be used – in tandem. Similarly, procurement practices such as multi-party contracts (Brahm and Tarziján, 2015) and project alliancing (Walker and Jacobsson, 2014) aim for increased levels of collaboration and can serve as an overall guidance, influencing the governance structures of the project. Thus, project managers and researchers interested in supply chain management for performance improvement should not only seek inter-firm collaboration mechanisms, but also implement and promote governance approaches and procurement practices that can foster and create a solid basis for inter-firm collaboration and coordination.

Second, the multi-faceted forms of performance in megaprojects are observed. As seen in the results, many forms of performance are described by the literature and they vary according to the categories and subcategories, as well as the respective level of analysis. Performance can be attributed to financial and economic aspects (Shi et al., 2018), higher productivity levels (Wickramatillake et al., 2007), increased collaboration and coordination among firms (Chakkol et al., 2018), improved quality (Wu et al., 2013), cost reduction (Ekeskär and Rudberg, 2016), integration and socialisation of teams and individuals (Aaltonen and Turkulainen, 2018), and others. Performance also varies over time and in the intra-, inter-, and macro-organisational levels, which opens opportunities for multi-level and network approaches. This dynamic configuration also reflects on the different perceptions of performance based on

different actors in the megaproject such as external stakeholders or communities, clients, contractors, suppliers, etc. Therefore, performance in megaproject supply chains can be described as any observed or desired positive outcomes from the perspectives of individual actors or collectives of actors, which can be dynamic, nonlinear, and even conflicting.

Third, network perspectives are powerful as they naturally enable multi-level approaches due to its potential to understand flows and relationships at micro, meso, and macro levels within the same analysis. Thus, it serves as a solid theoretical perspective for any of the other categories. The understanding of the network structures and attributes, for instance, can be used to comprehend and identify misaligned objectives and unclear roles and responsibilities of actors, which influence inter-firm collaboration and are influenced by governance mechanisms and approaches. The temporary aspects of networks are also important to create and develop better knowledge and coordination mechanisms and understand how they are influenced by the macro-environment. Networked flows of information, products and services can also be valuable to both practice and theory to better understand procurement and inter-firm coordination processes. Overall, network approaches provide a useful theoretical lens that view megaprojects, its supply chain, and its macro-environment as a complex and networked endeavour, formed by clusters of different agents and with multiple temporalities.

This research aimed to provide a clearer definition of the multi-level configuration depicted in the supply chain of megaprojects, hopefully inspiring more rigorous studies across its multiple levels of analysis. As demonstrated, similar concepts can have different meanings depending on the context, background, and community of the authors. Therefore, it is important to establish a common ground to advance research as one. The presented framework and discussion provided in this paper might help researchers to understand their unit of analysis, concepts, and perspectives aimed to be explored. By defining a common language for levels, strategies, and practices, this research provides a pathway to advance towards a unified understanding of the systemic and dynamic configuration of performance in megaproject supply chains among different communities, such as OM and PM.

We conclude the discussion with the future implications for studies, which is presented next.

5.2. Future research

There are a few barriers that may undermine inter-firm collaboration. Costa et al. (2019) divide them into cultural, organisational, and industry. Industry barriers, specifically, have been not fully explored as they are outside the boundaries of the organisations and usually considered to be out of their field of action. More studies, with a macro-level and even multi-level research perspective, could detail those barriers and their impacts on megaproject suppliers, contractors, etc. Much discussion is provided on the types of mechanisms used to achieve coordination and collaboration between firms of the project, however, how those firms develop their competencies and how they learn to collaborate with other organisations in underexplored in the megaproject environment. Processual perspective and longitudinal case-study research are alternatives to conduct such studies (Chakkol et al., 2018). Regarding mechanisms, but connected with procurement, an interesting opportunity would be to understand which coordination mechanisms work better with different types of contracts, such as dyadic or multi-party contracts, and project delivery strategies (Ju et al., 2017).

Regarding governance, more studies could use network approaches to understand its mechanisms from a networked perspective, similar to what is seen in the governance approach from Ruuska et al. (2011), including contractors, subcontractors and other supplier tiers of the network. It could also be expanded to the macro-level by, for instance, exploring mechanism to monitor external stakeholders, and overall socio-cultural and economic aspects and how to operationalise them (Kujala et al., 2020). The governance approaches such as the ones from von Danwitz (2018) and Ruuska et al. (2011) could use more empirical cases to test their designs and effectiveness, suggest new approaches or understand their similarities. Another interesting point would be to see more governance studies at the intra-organisational. Such studies would likely be multi-level, trying to measure impacts and effects of megaproject governance on individual contractors, subcontractors, or other suppliers from diverse tiers.

Sustainable, social, and green procurement is also an important topic which received little attention from the supply chain perspective in megaprojects. More techniques that foster sustainability in procurement practices, such as the competitive dialogue procedure, could be studied and proposed. Sustainable procurement also provides an opportunity to integrate collaboration mechanisms as early involvement of suppliers and thus the benefits of such mechanisms could be assessed from the sustainable procurement perspective (Uttam and Le Lann Roos, 2015). Young et al. (2018) determine which project characteristics are suitable for a project alliancing. Still, they focus mostly on intra- and inter-characteristics of projects, creating an opportunity for research to understand alliancing suitability including macro-organisational aspects such as location, affected communities, economic drivers, and political elements.

Projects as networks provides a promising perspective to understand the inherent complexity of megaproject supply chains. Still, relevant topics such as project complexity and temporary networks tend to appear more as characteristics or secondary aspects of the supply chain of megaprojects. Research can focus on temporary aspects and understand the relationships between clusters of permanent suppliers & supply chains and temporary project organisations. Researchers could also discuss the implications of abandoning the temporary view of multi-firm projects, as suggested by Ruuska et al. (2011). A network approach can also be a powerful tool to conduct multi-level research due to its natural capability to understand flows and relationships at individual and macro levels. Thus it can provide meaningful insights on the roles, responsibilities, and capabilities of the actors of the supply chain, including network orchestrators, supply chain managers, and systems integrators (Denicol et al., 2020).

Both production & logistics strategies and risk management should incorporate more macro aspects in their studies. Production strategies could use benchmarking studies – such as the one presented by (Yun et al., 2016) – comparing the megaproject supply chain with other supply chains to better understand the reasons of its low productivity levels when compared to other supply chains (Denicol et al., 2020). Interestingly, most of the elements under risk management focused on the intra- and inter-organisational levels. Therefore, risk

management could also suggest industry-wide comparative research to evaluate what other alternatives and terms could be adapted to megaprojects (Rudolf and Spinler, 2018).

6. Conclusion

In this paper, we aimed to consolidate the overall concepts, terminologies, and perspectives regarding strategies for performance improvement in the management of supply chains in megaprojects. A systematic literature review was conducted, and six main categories of strategies were found: inter-firm coordination and collaboration; governance; procurement; projects as networks; production and logistics strategies; and risk management. Those categories are further detailed into subcategories and classified into three levels of analysis – intra-, inter-, and macro-organisational – based in the supply chain as the unit of analysis.

Our academic contribution lies in the definition of nested levels, the identification of strategies and practices, the different perspectives found in the literature and the several future research avenues discussed. Our framework can support researchers in finding opportunities of studies as well as guide the level of analysis, even identifying and proposing promising multi-level approach research. We also demonstrate opportunities for multiple and cross perspective research. Our study also has implications for practitioners, as the categories are detailed thoroughly, the discussion provides many expected outcomes, results, and benefits from practical application of the strategies presented. The analysis and framework can support managers in understanding the overall picture of the megaproject supply chain and the connections among its diverse strategies.

References

Aaltonen, K. and Turkulainen, V. (2018) Creating relational capital through socialization in project alliances. *International Journal of Operations and Production Management*, 38 (6): 1387–1421. doi:10.1108/IJOPM-02-2017-0091.

Adami, V.S. and Verschoore, J.R. (2018) Implications of Network Relations for the Governance of Complex Projects. *Project Management Journal*, 49 (2): 71–88. doi:10.1177/875697281804900205.

Ahola, T. (2018) So alike yet so different: A typology of interorganisational projects. *International Journal of Project Management*, 36 (8): 1007–1018. doi:10.1016/j.ijproman.2018.07.005.

Akobeng, A.K. (2005) Understanding systematic reviews and meta-analysis. *Archives of Disease in Childhood*. doi:10.1136/adc.2004.058230.

Artto, K. and Turkulainen, V. (2018) It takes two to tango: Product-organization interdependence in managing major projects. *International Journal of Operations and Production Management*, 38 (6): 1312–1339. doi:10.1108/IJOPM-12-2016-0767.

Azambuja, M. and O'Brien, W.J. (2009) "Construction supply chain modeling: Issues and perspectives." In *Construction Supply Chain Management Handbook*. Boca Raton. pp. 2-1-2–31.

Bakker, R.M., DeFillippi, R.J., Schwab, A., et al. (2016) Temporary Organizing: Promises, Processes, Problems. *Organization Studies*, 37 (12): 1703–1719. doi:10.1177/0170840616655982.

Ballard, G. and Howell, G.A. (1998) "WHAT KIND OF PRODUCTION IS CONSTRUCTION?" In *6th Annual Conference of the International Group for Lean Construction*. Guarujá, Brazil, 1998.

Bekker, M.C. (2014) Project governance: "schools of thought." *South African Journal of Economic and Management Sciences*, 17 (1): 22–32. doi:10.4102/sajems.v17i1.595.

Boateng, P., Chen, Z. and Ogunlana, S.O.S.O. (2015) An Analytical Network Process model for risks prioritisation in megaprojects. *International Journal of Project Management*, 33 (8): 1795–1811. doi:10.1016/j.ijproman.2015.08.007.

Boland Jr., R.J., Sharma, A.K., Afonso, P.S., et al. (2008) Designing management control in hybrid organizations: The role of path creation and morphogenesis. *Accounting, Organizations and Society*, 33 (7–8): 899–914. doi:10.1016/j.aos.2008.06.006.

Bouraoui, D. and Lizarralde, G. (2013) Centralized decision making, users' participation and satisfaction in post-disaster reconstruction: The case of Tunisia. *International Journal of Disaster Resilience in the Built Environment*, 4 (2): 145–167. doi:10.1108/IJDRBE-02-2012-0009.

Brady, T. (2011) Creating and sustaining a supply network to deliver routine and complex one-off airport infrastructure projects. *International Journal of Innovation and Technology Management*, 8 (3): 469–481. doi:10.1142/S0219877011002362.

Brahm, F. and Tarziján, J. (2015) Does complexity and prior interactions affect project procurement? Evidence from mining mega-projects. *International Journal of Project Management*, 33 (8): 1851–1862. doi:10.1016/j.ijproman.2015.08.005.

Brintrup, A., Wang, Y. and Tiwari, A. (2017) Supply Networks as Complex Systems: A Network-Science-Based Characterization. *IEEE SYSTEMS JOURNAL*, 11 (4): 2170–

2181. doi:10.1109/JSYST.2015.2425137.

Brookes, N., Sage, D., Dainty, A., et al. (2017) An island of constancy in a sea of change: Rethinking project temporalities with long-term megaprojects. *International Journal of Project Management*, 35 (7): 1213–1224. doi:10.1016/j.ijproman.2017.05.007.

Bugrov, O. and Bugrova, O. (2018) Formalization of selection of contract-organizational project delivery strategy. *Eastern-European Journal of Enterprise Technologies*, 6 (3 (96)): 28–40. doi:10.15587/1729-4061.2018.151863.

Caldas, C.H., Menches, C.L., Reyes, P.M., et al. (2015) Materials Management Practices in the Construction Industry. *Practice Periodical on Structural Design and Construction*, 20 (3). doi:10.1061/(ASCE)SC.1943-5576.0000238.

Carter, C.R. and Easton, P.L. (2011) Sustainable supply chain management: Evolution and future directions. *International Journal of Physical Distribution and Logistics Management*, 41 (1): 46–62. doi:10.1108/09600031111101420.

Cerezo-Narváez, A., Otero-Mateo, M., Rodríguez-Pecci, F., et al. (2018) Digital transformation of requirements in the industry 4.0: Case of naval platforms. *Dyna (Spain)*, 93 (4): 448–456. doi:10.6036/8636.

Chakkol, M., Selviaridis, K. and Finne, M. (2018) The governance of collaboration in complex projects. *International Journal of Operations & Production Management*, 38 (4): 997–1019. doi:10.1108/IJOPM-11-2017-0717.

Chen, H.L. (2015) Performance measurement and the prediction of capital project failure. *INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT*, 33 (6): 1393–1404. doi:10.1016/j.ijproman.2015.02.009.

Costa, F., Denis Granja, A., Fregola, A., et al. (2019) Understanding Relative Importance of Barriers to Improving the Customer-Supplier Relationship within Construction Supply Chains Using DEMATEL Technique. *Journal of Management in Engineering*, 35 (3): 1–13. doi:10.1061/(ASCE)ME.1943-5479.0000680.

Dainty, A.R.J. and Brooke, R.J. (2004) Towards improved construction waste minimisation: a need for improved supply chain integration? *Structural Survey*, 22 (1): 20–29. doi:10.1108/02630800410533285.

von Danwitz, S. (2018) Organizing inter-firm project governance – a contextual model for empirical investigation. *International Journal of Managing Projects in Business*, 11 (1): 144–157. doi:10.1108/IJMPB-07-2017-0072.

Davies, A., Gann, D. and Douglas, T. (2009) Innovation in megaprojects: Systems integration at London Heathrow terminal 5. *California Management Review*, 51 (2). doi:10.2307/41166482.

Davies, A. and Mackenzie, I. (2014) Project complexity and systems integration: Constructing the London 2012 Olympics and Paralympics Games. *International Journal of Project Management*, 32 (5): 773–790. doi:10.1016/j.ijproman.2013.10.004.

Denicol, J., Davies, A. and Krystallis, I. (2020) What Are the Causes and Cures of Poor Megaproject Performance? A Systematic Literature Review and Research Agenda. *Project Management Journal*, 51 (3): 328–345. doi:10.1177/8756972819896113.

Denicol, J., Davies, A. and Pryke, S. (2021) The organisational architecture of megaprojects. *International Journal of Project Management*, 39 (4): 339–350. doi:10.1016/j.ijproman.2021.02.002.

Denyer, D. and Tranfield, D. (2009) Producing a Systematic Review. *The SAGE Handbook of Organizational Research Methods*.

Du, J., Jing, H., Choo, K.-K.R., et al. (2020) An Ontology and Multi-Agent Based Decision Support Framework for Prefabricated Component Supply Chain. *Information Systems Frontiers*, 22 (6): 1467–1485. doi:10.1007/s10796-019-09941-x.

Edkins, A.J., Kurul, E., Maytorena-Sanchez, E., et al. (2007) The application of cognitive mapping methodologies in project management research. *International Journal of Project Management*, 25 (8): 762–772. doi:10.1016/j.ijproman.2007.04.003.

Eisenhardt, M. (1989) Building Theories from Case Study Research. *Academy of Management*, 14 (4): 532–550.

Ekeskär, A. and Rudberg, M. (2016) Third-party logistics in construction: the case of a large hospital project. *Construction Management and Economics*, 34 (3): 174–191. doi:10.1080/01446193.2016.1186809.

Eren, F. (2019) Top government hands-on megaproject management: the case of Istanbul's grand airport. *International Journal of Managing Projects in Business*, 12 (3): 666–693. doi:10.1108/IJMPB-02-2018-0020.

van Fenema, P.C., Rietjens, S. and van Baalen, P. (2016) Stability and reconstruction operations as mega projects: Drivers of temporary network effectiveness. *International Journal of Project Management*, 34 (5): 839–861. doi:10.1016/j.ijproman.2016.03.006.

Fernandes, A., Spring, M. and Tarafdar, M. (2018) Coordination in temporary organizations: Formal and informal mechanisms at the 2016 Olympics. *International Journal of Operations and Production Management*, 38 (6): 1340–1367. doi:10.1108/IJOPM-02-2017-0097.

Flyvbjerg, B. (2014) What you should know about megaprojects and why: An overview. *Project Management Journal*, 45 (2): 6–19. doi:10.1002/pmj.21409.

Flyvbjerg, B., Bruzelius, N. and Rothengatter, W. (2003) *MegaProjects and Risk: An Anatomy of Ambition*. Cambridge: Cambridge University Press.

Gaudenzi, B. and Qazi, A. (2020) Assessing project risks from a supply chain quality management (SCQM) perspective. *International Journal of Quality & Reliability Management*, ahead-of-p (ahead-of-print). doi:10.1108/IJQRM-01-2020-0011.

Genus, A. (1997a) Managing large-scale technology and inter-organizational relations: The case of the Channel Tunnel. *Research Policy*, 26 (2): 169–189. doi:10.1016/S0048-7333(97)00006-1.

Genus, A. (1997b) Unstructuring incompetence: Problems of contracting, trust and the development of the channel tunnel. *Technology Analysis and Strategic Management*, 9 (4): 419–436. doi:10.1080/09537329708524295.

Gosling, J., Naim, M. and Towill, D. (2013) A supply chain flexibility framework for engineer-to-order systems. *Production Planning and Control*, 24 (7): 552–556. doi:10.1080/09537287.2012.659843.

Gosling, J. and Naim, M.M. (2009) Engineer-to-order supply chain management: A literature review and research agenda. *International Journal of Production Economics*, 122 (2): 741–754. doi:10.1016/j.ijpe.2009.07.002.

Hall, D.M., Algiers, A. and Levitt, R.E. (2018) Identifying the Role of Supply Chain Integration Practices in the Adoption of Systemic Innovations. *Journal of Management in Engineering*, 34 (6). doi:10.1061/(ASCE)ME.1943-5479.0000640.

Harty, C. (2005) Innovation in construction: a sociology of technology approach. *BUILDING RESEARCH AND INFORMATION*, 33 (6): 512–522. doi:10.1080/09613210500288605.

Hellgren, B. and Stjernberg, T. (1995) Design and implementation in major investments - A project network approach. *Scandinavian Journal of Management*, 11 (4): 377–394. doi:10.1016/0956-5221(95)00020-V.

Hetemi, E., Jerbrant, A. and Mere, J.O. (2020) Exploring the emergence of lock-in in large-scale projects: A process view. *International Journal of Project Management*, 38 (1): 47–63. doi:10.1016/j.ijproman.2019.10.001.

Hietajärvi, A.-M., Aaltonen, K. and Haapasalo, H. (2017a) Managing integration in infrastructure alliance projects: Dynamics of integration mechanisms. *International Journal of Managing Projects in Business*, 10 (1): 5–31. doi:10.1108/IJMPB-02-2016-0009.

Hietajärvi, A.-M., Aaltonen, K. and Haapasalo, H. (2017b) Opportunity management in large projects: a case study of an infrastructure alliance project. *Construction Innovation*, 17 (3): 340–362. doi:10.1108/CI-10-2016-0051.

Hietajärvi, A.M.A.-M., Aaltonen, K., Haapasalo, H., et al. (2017c) What is project alliance capability? *International Journal of Managing Projects in Business*, 10 (2): 404–422. doi:10.1108/IJMPB-07-2016-0056.

Hitt, M.A., Beamish, P.W., Jackson, S.E., et al. (2007) Building Theoretical and Empirical Bridges Across Levels: Multilevel Research in Management. *Academy of Management Journal*, 50 (6): 1385–1399. doi:10.5465/amj.2007.28166219.

Hu, Y., Chan, A.P.C., Le, Y., et al. (2015) From construction megaproject management to complex project management: Bibliographic analysis. *Journal of Management in Engineering*, 31 (4): 1–11. doi:10.1061/(ASCE)ME.1943-5479.0000254.

Jagtap, M. and Kamble, S. (2015) Evaluating the modus operandi of construction supply chains using organisation control theory. *International Journal of Construction Supply Chain Management*, 5 (1): 16–33. doi:10.14424/ijcscm501015-16-33.

Jagtap, M. and Kamble, S. (2019) An empirical assessment of relational contracting model for supply chain of construction projects. *International Journal of Managing Projects in Business*, 13 (7): 1537–1560. doi:10.1108/IJMPB-05-2018-0097.

Janné, M. and Rudberg, M. (2020) Effects of employing third-party logistics arrangements in construction projects. *Production Planning and Control*, 0 (0): 1–13. doi:10.1080/09537287.2020.1821925.

Jost, G., Dawson, M. and Shaw, D. (2005) Private sector consortia working for a public sector client - Factors that build successful relationships: Lessons from the UK. *European Management Journal*, 23 (3): 336–350. doi:10.1016/j.emj.2005.04.012.

Ju, Q., Ding, L. and Skibniewski, M.J. (2017) Optimization strategies to eliminate interface conflicts in complex supply chains of construction projects. *Journal of Civil Engineering and Management*, 23 (6): 712–726. doi:10.3846/13923730.2016.1232305.

Klijn, E.-H.E.H., Edelenbos, J., Kort, M., et al. (2008) Facing management choices: An analysis of managerial choices in 18 complex environmental public-private partnership projects. *International Review of Administrative Sciences*, 74 (2): 251–282. doi:10.1177/0020852308089905.

Kovács, G.L., Paganelli, P., Kovacs, G.L., et al. (2003) A planning and management infrastructure for large, complex, distributed projects - Beyond ERP and SCM.

Computers in Industry, 51 (2): 165–183. doi:10.1016/S0166-3615(03)00034-4.

Kujala, J., Aaltonen, K., Gotcheva, N., et al. (2020) Dimensions of governance in interorganizational project networks. *International Journal of Managing Projects in Business*, (June 2016): 1–4. doi:10.1108/IJMPB-12-2019-0312.

Lavikka, R.H., Smeds, R. and Jaatinen, M. (2015) Coordinating collaboration in contractually different complex construction projects. *Supply Chain Management*, 20 (2): 205–217. doi:10.1108/SCM-10-2014-0331.

Le, P.L., Jarroudi, I., Dao, T.-M., et al. (2020) Integrated construction supply chain: an optimal decision-making model with third-party logistics partnership. *Construction Management and Economics*. doi:10.1080/01446193.2020.1831037.

Lenfle, S. and Söderlund, J. (2019) Large-Scale Innovative Projects as Temporary Trading Zones: Toward an Interlanguage Theory. *Organization Studies*, 40 (11): 1713–1739. doi:10.1177/0170840618789201.

Loosemore, M. (2016) Social procurement in UK construction projects. *International Journal of Project Management*, 34 (2): 133–144. doi:10.1016/j.ijproman.2015.10.005.

Van Marrewijk, A. (2005) Strategies of cooperation: Control and commitment in mega-projects. *Management*, 8 (4): 89–104. doi:10.3917/mana.084.0089.

Van Marrewijk, A., Ybema, S., Smits, K., et al. (2016) Clash of the Titans: Temporal Organizing and Collaborative Dynamics in the Panama Canal Megaproject. *Organization Studies*, 37 (12): 1745–1769. doi:10.1177/0170840616655489.

Martinsuo, M. and Ahola, T. (2010) Supplier integration in complex delivery projects: Comparison between different buyer-supplier relationships. *International Journal of Project Management*, 28 (2): 107–116. doi:10.1016/j.ijproman.2009.09.004.

Merrow, E.W. (2011) *Industrial Megaprojects: Concepts, Strategies, and Practices for Success*. Hoboken: John Wiley & Sons Ltd.

Miller, R. and Hobbs, B. (2005) Governance Regimes for Large Complex Projects. *Project Management Journal*, 36 (3): 42–50. doi:10.1177/875697280503600305.

Mohagheghi, V., Mousavi, S.M., Mojtahedi, M., et al. (2020) Introducing a multi-criteria evaluation method using Pythagorean fuzzy sets. *Kybernetes*, ahead-of-p (ahead-of-print). doi:10.1108/K-04-2019-0225.

Morandi, M.I.W.M. and Camargo, L.F.R. (2015) “Systematic Literature Review.” In *Design Science Research*. Springer International Publishing. pp. 129–158. doi:10.1007/978-3-319-07374-3_7.

Musawir, A. ul, Abd-Karim, S.B. and Mohd-Danuri, M.S. (2020) Project governance and its role in enabling organizational strategy implementation: A systematic literature review. *International Journal of Project Management*, 38 (1): 1–16. doi:10.1016/j.ijproman.2019.09.007.

Nasir, H., Haas, C.T., Young, D.A., et al. (2010) An implementation model for automated construction materials tracking and locating. *Canadian Journal of Civil Engineering*, 37 (4): 588–599. doi:10.1139/L09-178.

Pauget, B. and Wald, A. (2013) Relational competence in complex temporary organizations: The case of a French hospital construction project network. *International Journal of Project Management*, 31 (2): 200–211. doi:10.1016/j.ijproman.2012.07.001.

Pinto, J.K., Slevin, D.P. and English, B. (2009) Trust in projects: An empirical assessment of owner/contractor relationships. *International Journal of Project*

Management, 27 (6): 638–648. doi:10.1016/j.ijproman.2008.09.010.

Qazi, A., Quigley, J., Dickson, A., et al. (2016) Project Complexity and Risk Management (ProCRiM): Towards modelling project complexity driven risk paths in construction projects. *INTERNATIONAL JOURNAL OF PROJECT MANAGEMENT*, 34 (7): 1183–1198. doi:10.1016/j.ijproman.2016.05.008.

De Rezende, L.B., Blackwell, P. and Pessanha Gonçalves, M.D. (2018) Research Focuses, Trends, and Major Findings on Project Complexity: A Bibliometric Network Analysis of 50 Years of Project Complexity Research. *Project Management Journal*, 49 (1): 42–56. doi:10.1177/875697281804900104.

Riazi, S.R.M., Nawi, M.N.M., Salleh, N.A., et al. (2019) Collaborative supply chain management (SCM) tools for improved teamwork in construction projects. *International Journal of Supply Chain Management*, 8 (5): 473–480.

Rudolf, C.A. and Spinler, S. (2018) Key risks in the supply chain of large scale engineering and construction projects. *Supply Chain Management*, 23 (4): 336–350. doi:10.1108/SCM-09-2017-0292.

Ruuska, I., Ahola, T., Artto, K., et al. (2011) A new governance approach for multi-firm projects: Lessons from Olkiluoto 3 and Flamanville 3 nuclear power plant projects. *International Journal of Project Management*, 29 (6): 647–660. doi:10.1016/j.ijproman.2010.10.001.

Ruuska, I., Artto, K., Aaltonen, K., et al. (2009) Dimensions of distance in a project network: Exploring Olkiluoto 3 nuclear power plant project. *International Journal of Project Management*, 27 (2): 142–153. doi:10.1016/j.ijproman.2008.09.003.

Safa, M., Shahi, A., Haas, C.T., et al. (2017) Construction contract management using value packaging systems. *International Journal of Construction Management*, 17 (1): 50–64. doi:10.1080/15623599.2016.1167369.

Seuring, S. and Gold, S. (2012) Conducting content-analysis based literature reviews in supply chain management Wilding, R. (ed.). *Supply Chain Management: An International Journal*, 17 (5): 544–555. doi:10.1108/13598541211258609.

Shi, Q., Zhu, J. and Li, Q. (2018) Cooperative Evolutionary Game and Applications in Construction Supplier Tendency. *Complexity*, 2018. doi:10.1155/2018/8401813.

Smith, V., Devane, D., Begley, C.M., et al. (2011) Methodology in conducting a systematic review of systematic reviews of healthcare interventions. *BMC Medical Research Methodology*. doi:10.1186/1471-2288-11-15.

Steen, J., Ford, J.A. and Verreynne, M.-L. (2017) Symbols, Sublimes, Solutions, and Problems: A Garbage Can Model of Megaprojects. *Project Management Journal*, 48 (6): 117–131. doi:10.1177/875697281704800609.

Sydow, J. and Braun, T. (2018) Projects as temporary organizations: An agenda for further theorizing the interorganizational dimension. *International Journal of Project Management*, 36 (1): 4–11. doi:10.1016/j.ijproman.2017.04.012.

Szentes, H. (2018) Reinforcing cycles involving inter- and intraorganizational paradoxical tensions when managing large construction projects. *Construction Management and Economics*, 36 (3): 125–140. doi:10.1080/01446193.2017.1315826.

Tchokogué, A., Nollet, J. and Beaulieu, L. (2017) Supply management for major sport events: The case of the 2010 Vancouver Olympic Games. *Canadian Journal of Administrative Sciences*, 34 (1): 7–18. doi:10.1002/cjas.1374.

Teizer, J. (2015) Status quo and open challenges in vision-based sensing and tracking of temporary resources on infrastructure construction sites. *Advanced Engineering Informatics*, 29 (2): 225–238. doi:10.1016/j.aei.2015.03.006.

Thomé, A.M.T., Scavarda, L.F., Scavarda, A., et al. (2016) Similarities and contrasts of complexity, uncertainty, risks, and resilience in supply chains and temporary multi-organization projects. *International Journal of Project Management*, 34 (7): 1328–1346. doi:10.1016/j.ijproman.2015.10.012.

Thürer, M., Tomašević, I., Stevenson, M., et al. (2020) A systematic review of China's belt and road initiative: implications for global supply chain management. *International Journal of Production Research*, 58 (8): 2436–2453. doi:10.1080/00207543.2019.1605225.

Toor, S.U.R.S.-U.-R. and Ogunlana, S. (2008) Problems causing delays in major construction projects in Thailand. *Construction Management and Economics*, 26 (4): 395–408. doi:10.1080/01446190801905406.

Tóth, Z., Peters, L.D., Pressey, A., et al. (2018) Tension in a value co-creation context: A network case study. *Industrial Marketing Management*, 70: 34–45. doi:10.1016/j.indmarman.2017.08.015.

Tranfield, D., Denyer, D. and Smart, P. (2003) Towards a Methodology for Developing Evidence-Informed Management Knowledge by Means of Systematic Review. *British Journal of Management*, 14 (3): 207–222. doi:10.1111/1467-8551.00375.

Uttam, K. and Le Lann Roos, C. (2015) Competitive dialogue procedure for sustainable public procurement. *Journal of Cleaner Production*, 86: 403–416. doi:10.1016/j.jclepro.2014.08.031.

Walker, D. and Jacobsson, M. (2014) A rationale for alliancing within a public-private partnership. *Engineering, Construction and Architectural Management*, 21 (6): 648–673. doi:10.1108/ECAM-09-2013-0087.

Walsh, K.D., Hershauer, J.C., Tommelein, I.D., et al. (2004) Strategic positioning of inventory to match demand in a capital projects supply chain. *Journal of Construction Engineering and Management*, 130 (6): 818–826. doi:10.1061/(ASCE)0733-9364(2004)130:6(818).

Wang, D., Fang, S. and Fu, H. (2019) Impact of Control and Trust on Megaproject Success: The Mediating Role of Social Exchange Norms. *ADVANCES IN CIVIL ENGINEERING*, 2019. doi:10.1155/2019/4850921.

Wickramatillake, C.D., Koh, S.C.L., Gunasekaran, A., et al. (2007) Measuring performance within the supply chain of a large scale project. *Supply Chain Management*, 12 (1): 52–59. doi:10.1108/13598540710724338.

Winch, G.M. (2014) Three domains of project organising. *International Journal of Project Management*, 32 (5): 721–731. doi:10.1016/j.ijproman.2013.10.012.

Wood, D.A. (2017) High-level integrated deterministic, stochastic and fuzzy cost-duration analysis aids project planning and monitoring, focusing on uncertainties and earned value metrics. *Journal of Natural Gas Science and Engineering*, 37: 303–326. doi:10.1016/j.jngse.2016.11.045.

Wu, Y., Yang, Y., Wang, Z., et al. (2013) Macro quality chain management and coordination optimization research. *Journal of Software*, 8 (8): 2023–2031. doi:10.4304/jsw.8.8.2023-2031.

Yang, D., He, Q., Cui, Q., et al. (2018) Organizational Citizenship Behavior in

Construction Megaprojects. *Journal of Management in Engineering*, 34 (4). doi:10.1061/(ASCE)ME.1943-5479.0000614.

Young, B., Hosseini, A., Klakegg, O.J., et al. (2018) What makes an alliance an alliance. *Journal of Modern Project Management*, 6 (1): 18–29. doi:10.19255/JMPM01602.

Yun, S., Choi, J., Oliveira, D.P., et al. (2016) Measuring project management inputs throughout capital project delivery. *International Journal of Project Management*, 34 (7): 1167–1182. doi:10.1016/j.ijproman.2016.06.004.

Zeng, W., Wang, H., Li, H., et al. (2019) Incentive Mechanisms for Supplier Development in Mega Construction Projects. *IEEE Transactions on Engineering Management*, 66 (2): 252–265. doi:10.1109/TEM.2018.2808169.

Zerjav, V., Edkins, A. and Davies, A. (2018) Project capabilities for operational outcomes in inter-organisational settings: The case of London Heathrow Terminal 2. *International Journal of Project Management*, 36 (3): 444–459. doi:10.1016/j.ijproman.2018.01.004.

Zhang, J., Qi, X. and Liang, C. (2018) Tackling Complexity in Green Contractor Selection for Mega Infrastructure Projects: A Hesitant Fuzzy Linguistic MADM Approach with considering Group Attitudinal Character and Attributes' Interdependency. *Complexity*, 2018: 1–31. doi:10.1155/2018/4903572.

Zhang, L., Yuan, J., Xia, N., et al. (2020) Improving Information Sharing in Major Construction Projects through OC and POC: RDT Perspective. *JOURNAL OF CONSTRUCTION ENGINEERING AND MANAGEMENT*, 146 (7). doi:10.1061/(ASCE)CO.1943-7862.0001847.

Zhao, N. (2019) Managing interactive collaborative mega project supply chains under infectious risks. *International Journal of Production Economics*, 218 (May 2019): 275–286. doi:10.1016/j.ijpe.2019.06.008.

Zhu, J., Fang, M., Shi, Q., et al. (2018) Contractor cooperation mechanism and evolution of the green supply chain in mega projects. *Sustainability (Switzerland)*, 10 (11). doi:10.3390/su10114306.

APPENDIX

APPENDIX A – Systematic Literature Review Protocol

Search Strategy Protocol		
Conceptual Framework:	The performance of supply chain in project-based industries, especially in complex inter-organisational environments.	
Context:	Complex, temporary organisations, large infrastructure projects.	
Horizon	There was no limitation regarding the timespan of the publications.	
Theoretical perspectives:	Supply Chain Management; Management of Projects; Megaprojects;	
Languages	English	
Review question:	What are the strategies and practices used for performance improvement at the different levels of the megaproject supply chains and what are their impacts across the interorganisational network?	
Review Strategy	( ) Aggregative	(X) Configurative
Search Criteria	Inclusion criteria Papers related to megaprojects, large capital projects, complex environments, etc.	Exclusion criteria Papers not related to megaprojects, conference papers, other non-peer reviewed sources (books, reports, etc.), documents not in English.
Search terms	As seen in Table 1 and Table 2.	
Search sources		
Databases:	Scopus Web of Science	

APPENDIX B – Coding Structure Example

Paper	Paper level coding		Evidence	Node level coding				Metrics	
	Category	Subcategory		Node Name	Interface	Sub	Level	Paper	Nodes
(Denicol et al., 2020)	Projects as Networks	Supply Networks	"(...) better understand how novel organizational forms and governance structures between owners, operators, sponsors, clients, delivery partners, and suppliers are being developed to improve the performance of megaprojects (Gil & Pinto, 2018)." "(...) focus on improving our understanding regarding the roles, responsibilities, and capabilities of permanent and temporary organizations that are part of the network—from owners to suppliers such as meta- systems integrators (Davies & Mackenzie, 2014), network orchestrators, supply chain architects (Denicol, 2020a), supply chain managers, and systems integrators (Nambisan & Sawhney, 2011; Wind et al., 2009)."	Designing the system architecture	Projects as Networks	Supply Networks	Inter-organisational	1	5
			"(...) Considering the productivity gap between construction and other industries, there is a need for more research to examine how manufacturing production strategies (e.g., Engineer-to-Order, Assembly-to-Order, and Make-to-Stock) and advanced digital technologies (e.g., augmented reality and artificial intelligence) may be applied to complete megaprojects more efficiently and effectively (Gosling & Naim, 2009)." "Researchers might examine how off- site manufacturing, modu- larity, platforms, just- time- time logistics, and new techniques such as Design for Manufacture and Assembly (DfMA) and arti- ficial intelligence are being applied to enhance the performance of megaproject production systems."	Bridging the gap with manufacturing	Production & Logistics Strategies	Production Strategies	Intra-organisational		
			"Researchers might explore how different leadership approaches can be adopted to address, match, and cope with current and new organizational forms. Another opportunity is to study the interplay between the formation of the team, recruiting and building the necessary competencies in a bottom- up approach, and the desired organizational capability (Edmondson & Harvey, 2017)."	Building and leading collaborations	Inter-firm Coordination & Collaboration	Social aspects, communication & Mechanisms	Inter-organisational		
			"Given the extensive infrastructure development in emerging regions—such as Africa, parts of Asia, and South America—there are concerns about the strength of the institutional environment in those places and how mature practices from developed centers could be transferred and applied (Gil et al., 2019)." "Researchers might explore how the infrastructure will be constructed when embedded in a context with weak institutions, changing and emerging regulatory frameworks, and high levels of corruption (Locatelli, Mariani et al., 2017). There is a need to identify and explore how institutional and cultural contexts impact on the planning and execution of megaprojects in different parts of the world."	Engaging institutions and communities	Governance	Governance Approaches	Macro-organisational		
			"There is a need for more guidance on the rules, procedures, and methods enabling clients to know how to break down each project supply chain into manageable packages and modules." "Research could explore how clients use influence and negotiation skills to manage multiple contracts, including how to balance the competing interests, different behaviors, and priorities of numerous suppliers involved in a megaproject (Pryke, 2020). Studies might examine how suppliers are incentivized to achieve their objectives during different stages and transitions in the life cycle of a megaproject—from the front- end planning, through design and construction, to the back- end handover to operations (Hart, 2015)."	Decomposing and integrating the supply chain	Inter-firm Coordination & Collaboration	Coordination, Collaboration & Mechanisms	Inter-organisational		

Paper	Paper level coding		Evidence	Node level coding				Metrics	
	Category	Subcategory		Node Name	Interface	Sub	Level	Paper	Nodes
(Ruuska et al., 2009)	Projects as Networks	Network Structures	"(...) holistic view to analyze complex multi-firm project networks and their management." "Literature on large projects can be seen as two-fold: the first stream discusses problems that increase distance, such as disruption and delay and risks, differing interests and institutional and cultural differences. The second stream discusses actions for reducing distance, such as project governance. Our distance framework integrates the individual firm related and network related distance elements (c.f. the first stream referred to above), and practices that affect the distance either by increasing or reducing it (c.f. the second stream referred to above)"	Distance framework	Governance	Project Structure	Inter-organisational	1	4
			"(...) affect the distance through each individual firm's characteristics, including: lack of experience and capabilities, incomplete systems and processes, potential hidden agendas, and lack of knowledge of specific (local) requirements."	Firm attributes	Governance	Governance Mechanisms	Intra-organisational		
			"(...) describe the distance through the relationships of the actors and they include: misaligned objectives, unclear roles and responsibilities, lack of trust, action or inaction based on assumptions (rather than facts), no previous joint working experience, and diversity of actors."	Network attributes	Inter-firm Coordination & Collaboration	Coordination, Collaboration & Mechanisms	Inter-organisational		
			"(...) decrease or increase the distance in the network. Project practices comprise incomplete quotation information, inappropriate selection principles of suppliers and contractors, inadequate documentation procedures, insufficient communication structures and mismatch between the communication purpose and style, and inappropriate contract types and adherence to the contracts."	Project Practices	Procurement	Procurement Operations	Inter-organisational		
Total								**2**	**9**

Source: Original.