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What are the strategies to manage megaproject supply chains? A systematic literature review and research agenda

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A R T I C L E I N F O

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A B S T R A C T

This systematic literature review explores strategies to manage complex supply chains in megaprojects, connecting project management and operations management literatures. A total of 2,106 titles and abstracts were analyzed and 94 papers were fully reviewed, identifying six categories of strategies: inter-firm collaboration and coordination, governance, procurement, projects as networks, production and logistics, and risk management. We present the multi-level Megaproject Supply Chain (MSC) framework, unpacking the complex inter-organizational structure of megaprojects in five levels and units of analysis to guide future research. The MSC framework identifies the micro, meso and macro levels of megaprojects and introduces two additional hybrid levels to identify inter-organizational relationships: the meso-micro and meso-macro. We suggest four avenues to advance supply chain management in megaprojects through multi-level explorations: (i) Supply Chain Structure: Permanent vs Temporary, (ii) Strategic Procurement and Commercial, (iii) Supply Chain Design: Standardization vs Customization, (iv) Supply Chain Governance: Collaboration and Coordination.

1. Introduction

Driven by the growing share of project activities – or "projectification' – in almost every organization and industry (Midler, 1995; Parvan, Rahmandad & Haghani, 2015), project management (PM) became an important part of operations management (OM) research and practice. Although projects and operations can be considered distinct (Ramasesh & Browning, 2014), OM research has traditionally provided different contributions to project contexts, such as models to improve project capacity utilization and planning (Narayanan, Balasubramanian, Swaminathan & Zhang, 2020), planning tools for high-risk projects (Zwikael & Sadeh, 2007), and the effects of control on project performance (Liu, 2015). However, a more specific category of project known as 'megaprojects' has increasingly gained space in both PM and OM research given the rapid growth of such large-scale, complex endeavors around the globe in recent decades (Artto & Turkulainen, 2018; Browning, 2010; Denicol, Davies & Krystallis, 2020; Flyvbjerg, 2014). As a proxy for large-scale, megaprojects have been defined as costing more than US$1 billion and require long-term effort and resources to develop and build (Flyvbjerg, Bruzelius & Rothengatter, 2003; Merrow, 2011). They are known for their inefficient management, wasteful use of resources and constant overruns in terms of costs and schedule (Denicol et al., 2020; Flyvbjerg, 2014). Megaprojects have their own internal economy, system of production, and governance structures (Davies, Gann & Douglas, 2009). Each megaproject is comprised of multiple, dependent, and inter-organizational subprojects and many different stakeholders with diverging interests and often conflicting priorities (Denicol, Davies & Pryke, 2021). The scale, complexity and ambition of megaprojects set them apart from traditional projects (Brady & Davies, 2014; Van Marrewijk, Clegg, Pitsis & Veenswijk, 2008). This paper identifies how contributions from PM and OM can improve our understanding of how to manage the complex inter-organizational structures of this increasingly important phenomenon.

Supply chain management (SCM) is an important lens to understand the complexity of megaproject inter-organizational structures, practices and relationships, and consider how project success and efficiency may be improved (Maylor, Meredith, Söderlund & Browning, 2018). SCM, as the management of the network of upstream and downstream organizations that are involved (Christopher, 1992), is often a neglected domain in PM research. Extant research on megaproject management and supply chains is fragmented, as scholars attempt to address the complex temporality and inter-organizational nature of megaprojects

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through several lenses. OM research has until recently paid little attention to large, inter-organizational projects (Mishra & Browning, 2020). Previous research lacks a common set of terminologies and concepts (Thomé et al., 2016), creating gaps and overlaps in OM and PM literature (Turner, Aitken & Bozarth, 2018), which points out to a need to consolidate the discussions regarding megaprojects and supply chain structures.

We present a systematic literature review (SLR) to identify important PM and OM contributions, recognize the limits of each domain, and provide a synthesis of research on SCM in megaprojects. Our review investigates the following question: "What are the strategies used to manage megaproject supply chains?" The SLR identifies the concepts and theoretical perspectives scholars have introduced to understand the strategies used for performance improvement at the different levels of the megaproject supply chain. We adopt strategies as the broad term to capture the plans and actions to improve supply chain management in megaprojects, and consequently the performance of megaprojects.

In our study, we find that contributions from OM and PM provide important insights for understanding how megaproject supply chains are managed, but differ considerably in terms of concepts, frameworks and theoretical perspectives (Ahola, 2018; Gosling & Naim, 2009; Thomé et al., 2016).

We develop a multi-level perspective to better understand and decompose the whole inter-organizational structure of megaprojects, revealing the different permanent and temporary configurations. We contribute to the megaproject literature by identifying a set of strategies for SCM in megaprojects and proposing an integrated framework to better understand the multi-level configuration of nested organizational activities. The multi-level Megaproject Supply Chain (MSC) framework unpacks a complex inter-organizational structure and presents five levels and units of analysis to guide future research. The MSC framework identifies the micro, meso and macro levels of megaprojects and introduces two additional categories to identify novel inter-organizational relationships: the meso-micro and meso-macro.

This paper is organized as follows. In the next section, the research method is presented with a deeper explanation of how the SLR was conducted. Section 3 presents the data structure created to analyze the literature. Section 4 reports the results of the SLR, discussing the main strategies and practices found in the literature. Next, Section 5 introduces the MSC framework summarizing those strategies and practices, and presents a research agenda for future studies. Finally, Section 6 presents the concluding remarks.

2. Research method

2.1. The systematic literature review process

A systematic review identifies relevant information from a growing volume of publications that might be either similar or conflicting (Seuring & Gold, 2012). Research on a series of relevant studies is more appropriate than a limited set of studies, as it provides in a clear method an overall view of the literature, taking into account a vast range of findings around a research topic (Akobeng, 2005; Morandi & Camargo, 2015). The SLR was conducted in three stages as suggested by Denyer and Tranfield (2009) and Tranfield, Denyer and Smart (2003) and is compatible with Smith, Devane, Begley and Clarke (2011). The first stage starts with the creation of the search protocol, which describes the research question, the terms (or keywords) used, inclusion and exclusion criteria, and the databases used for the search (see Appendix A). The second stage refers to the search of the papers and their analysis, comprising the creation of the codes and categories, and the content analysis, to provide 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, organization, 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 used to generate 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 (refer to Appendix B for the complete structure of terms).

With the search protocol and the list of terms defined, we proceeded to search the Scopus and Web of Science (WOS) databases for 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, totalizing 3,572 documents. The search was conducted on 7 December 2020 with no limit regarding the timespan of the publications (see Appendix C for the results by each set).

All the documents generated by the search were consolidated on Mendeley to exclude duplicates. 1,362 duplicates were found and excluded, resulting in 2,210 documents. These were analysed and further 104 documents were excluded because they either had titles or abstracts missing, they were wrongly categorized as papers (being instead reports or maganizes and news articles) or further duplicates (with slightly different titles or authors' names). Thus, 2,106 documents were selected for the title and abstract analysis. For the analysis of the abstracts, we included all the papers referring in some way to megaprojects and supply chains. The authors discussed and reached a consensus on the selection of articles. In some cases, where it was not clear from the abstract and title if the paper was referring to megaprojects – such as mentioning "large capital projects" – they were included to be analyzed during the full reading of the papers and excluded later if found to be not relevant. Then, from the 2,106 papers' titles and abstracts analyzed, 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 and were excluded (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), resulting in a total of 94 papers included in this review (Appendix D shows the full list of papers). Fig. 1 presents a diagram demonstrating the SLR process applied in the research.

2.2. Coding method

To identify key aspects of our sample, we created several elements to classify the literature. Other than a few basic categories such as research objectives, findings, research methods, journal, and country, we created our categories of analysis utilizing an inductive category building approach. Therefore, our analytical categories were derived from the data and were constantly revised and refined, starting with the theoretical approaches and connecting the empirical findings (Eisenhardt, 1989; Seuring & Gold, 2012). We first created the category – theoretical lenses – to identify the main theories related to the megaproject supply chain context. We then identified significant clusters of knowledge that formed 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 used to identify how megaproject supply chain performance may be improved. Finally, we created the 'level' category represented by the intra-organizational, inter-organizational, and macro-organizational dimensions, which enabled us to understand the micro, meso, and macro levels of the analysis. Those categories are all presented in detail in the next section.

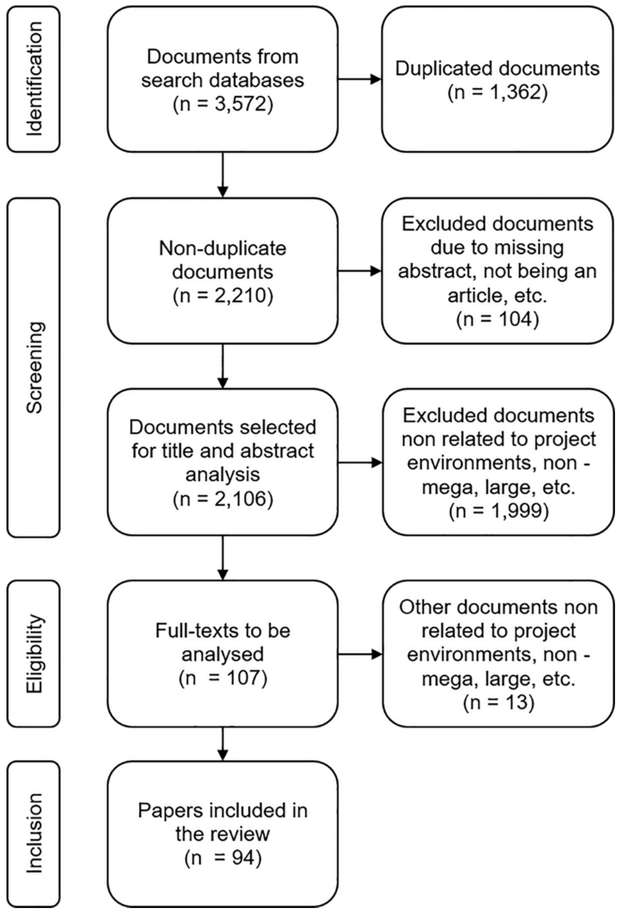


Fig. 1. SLR diagram.

3. Data analysis, structure, and descriptive statistics

3.1. Theoretical lenses and areas of knowledge

Our first step of the analysis was to identify the main theoretical lenses found in 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. To avoid any misconceptions or inconsistencies, we maintained a strict procedure to code theories that were clearly mentioned and/or stated by the authors in their papers. For papers that claimed to use multiple theoretical lenses, we aimed to determine the most predominant one and classify the paper as such. Most of the papers (50%) did not clearly state the theories upon which they are based. 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 to a still unconsolidated theoretical basis for both SCM and project management domains, which often draw concepts from different research fields, such as operations research, general management, and organization studies (Thomé et al., 2016).

Therefore, from a theoretical lens perspective, it was difficult to provide an accurate picture of the literature of studies addressing SCM in megaprojects. Our findings suggest that many papers presented their research backgrounds and contributions based on areas of knowledge rather than theories. Those areas of knowledge could be specific, such as innovation in construction (Harty, 2005) or procurement (Brahm & Tarziján, 2015), but overall they converged on 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 categorization was qualitative and based on the literature background of each paper, the context of the research, and the intended contributions claimed by the authors.

From the data, it can be seen that over 90% of the papers either referred to PM or OM. The computer science, simulation and optimization area of knowledge represented technical papers that focused on creating or evolving computational models and do not primarily relate to operations or project management literature. Examples of such papers are Du, Jing, Choo, Sugumaran and Castro-Lacouture (2020), and Teizer (2015). Similarly, decision sciences comprised of papers that focused on the understanding of decision-making and its theories, rather than computational models, and did not relate to OM or PM directly, such as Shi, Zhu and Li (2018). These last two areas of knowledge represented only 8,51% of our sample and therefore were not the focus of our analysis. Although OM and PM were the most predominant areas of knowledge within the context of the management of supply chains in megaprojects, they adopted a variety of concepts, different terminologies and independent perspectives on the same subject (Ahola, 2018; Gosling & Naim, 2009; Thomé et al., 2016). Our SLR aimed to connect and unify these PM and OM streams of research.

3.2. Supply chain strategies, interfaces, and levels

Utilizing the coding strategy described before, the literature was clustered to identify 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 subcategory as described in Appendix E. The resulting structure of categories and subcategories is presented and discussed in the next section.

Initially, the articles were classified by the predominant category and subcategory included in the papers. Table 1 shows the categories and the number of papers in each one of them. While this represented an overall and primary classification and relationships among categories and subcategories, we recognize that the content of the papers, and the coding structure is significantly more complex. Because we coded the key points of each paper to a category and subcategory, a paper could have multiple nodes of code for the same category/subcategory. It might also use the same code (or node) and at the same time refer to more than one category. To represent this behavior, we also mapped the interfaces between the categories – which draws upon the extensive coding process at the node level. This meant that a paper could 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), such as procurement and governance. The same rationale was applied to the subcategory level.

The data showed that inter-firm coordination and collaboration, and governance are the most significant categories in the literature, accounting for almost 60% of the total. Then, procurement, project as networks, production and logistics, and risk management represented over 40% of the overall articles. This classification is made at document level and represent the most predominant aspect of each paper. To provide a more detailed analysis, we coded relevant passages from the articles creating the nodes, which represented themes or ideas of the papers. Therefore, papers had only one main category coded at document level and several interfaces coded at node level (please refer to Appendix E for clarification).

The unit of analysis of our SLR is the megaproject supply chain, as the network of organizations involved in upstream and downstream activities (Christopher, 1992; Harland, 1996). We propose three dimensions to represent different levels of analysis: intra, inter, and macro-organizational which correspond to the micro, meso, and macro levels, in which: a) the micro level is concerned with the intra-organizational relations of the individual firms and organizations that comprise a megaproject; b) the meso level focus on the dyadic and extended inter-organizational relationships in the supply chain, such as clients, owners, and contractors; and c) the macro-environment of the supply chain which extends the analysis to social and political

Table 1
SLR Categories.

Category	Papers	%	References
Inter-firm Coordination and Collaboration	31	32,98%	Examples: (Chakkol, Selviaridis & Finne, 2018; Fernandes, Spring & Tarafdar, 2018; Jost, Dawson & Shaw, 2005; Lavikka, Smeds & Jaatinen, 2015; Martinsuo & Ahola, 2010; Riazi, Nawi, Salleh & Ahmad, 2019; Zhu, Fang, Shi, Wang & Li, 2018)
Governance	25	26,59%	Examples: (Eren, 2019; Jagtap & Kamble, 2015, 2019; Kujala, Aaltonen, Gotcheva & Lahdenperä, 2021; Ruuska, Ahola, Artto, Locatelli & Mancini, 2011; von Danwitz, 2018; Wang, Fang & Fu, 2019)
Procurement	11	11,70%	Examples: (Brahm & Tarziján, 2015; Bugrov & Bugrova, 2018; Hietajärvi, Aaltonen & Haapasalo, 2017a, 2017b; Loosemore, 2016; Uttam & Le Lann Roos, 2015; Young, Hosseini, Klakegg & Ládre, 2018)
Projects as Networks	10	10,64%	Examples: (Adami & Verschoore, 2018; Brintrup, Wang & Tiwari, 2017; Hellgren & Stjernberg, 1995; Ruuska, Artto, Aaltonen & Lehtonen, 2009; Thürer et al., 2020; van Fenema, Rietjens & van Baalen, 2016; Yang, He, Cui & Hsu, 2018)
Production and Logistics Strategies	10	10,64%	Examples: (Caldas, Menches, Reyes, Navarro & Vargas, 2015; Dainty & Brooke, 2004; Ekeskär & Rudberg, 2016; Janné & Rudberg, 2022; Le, Jarroudi, Dao & Chaabane, 2020; Nasir et al., 2010; Walsh, Hershauer, Tommelein & Walsh, 2004)
Risk Management	7	7,45%	Examples: (Boateng, Chen & Ogunlana, 2015; Gaudenzi & Qazi, 2020; Hietajärvi, Aaltonen & Haapasalo, 2017c; Mohagheghi, Mousavi, Mojtahedi & Newton, 2020; Qazi, Quigley, Dickson & Kirytopoulos, 2016; Rudolf & Spinler, 2018; Zhao, 2019)
Total	**94**	**100,00%**	

stakeholders, relationships of permanent layers of agents not directly inserted in the temporary megaproject organization, and industry-wide aspects. To present the connections and relationships among categories, interfaces and levels, a Sankey diagram is created and presented in Fig. 2.

The size of the flows linking one category to another in Fig. 2 represents the quantity of nodes found connecting those categories, following the structure of categories, interfaces, and levels described before and in Appendix E. This quantification – as well as the others that will follow – does not aim to be deterministic, but rather to provide a visual representation of the connections and complicated behavior across different topics and levels of analysis. For the inter-firm coordination and collaboration category, about half of the nodes remain within their own category – hence the link with inter-firm – but interface with governance, procurement, projects as networks, and risk management. From the level of analysis perspective, most inter-firm nodes refer to the inter-organizational level, but some representation of macro- and intra-organizational levels can also be discerned. Some categories are more self-contained, with few connections to other dimensions, such as production and logistics strategies, and risk management. Given the context and theoretical background of SCM, inter-organizational aspects are predominate, but insights for intra and macro-organizational levels – and potentially multi-level perspectives as well – can also be identified.

4. Results

In the results section, we describe each one of the categories, subcategories, and interfaces. Insights are drawn from the analysis of the literature and we discuss the strategies for SCM in megaprojects, the outcomes, improvements, risks, challenges, and avenues for solutions. We conclude the section with an overall picture of the strategies to improve the performance of megaproject supply chains, bringing up relevant aspects for a critical discussion.

4.1. *Inter-firm coordination and collaboration*

Inter-firm coordination and collaboration concern studies that mostly examine the inter-organizational relationships among the firms of large infrastructure projects, but also research focused on the macro environment or individual organizations. Many studies in this category explore elements of procurement, governance, networks, and risk management. Four main subcategories of inter-firm coordination and collaboration were found as shown in Appendix F, which uses the same structure as the previous Sankey diagram. Those subcategories are: coordination, collaboration, and mechanisms; project trust; social aspects, communications, and mechanisms; and supplier development, integration, and management.

4.1.1. *Coordination, collaboration, and mechanisms*

Mechanisms for coordination and collaboration of firms are basic elements in the structures of organizations combining 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 organizations in an unplanned and non-institutionalized manner (Chakkol et al., 2018; Fernandes et al., 2018). Some authors also use the perspective of temporary project networks to study mechanisms for coordination and collaboration. Artto and Turkulainen (2018) from an intra-organizational perspective, elaborate on the volume-variety matrix and point out the importance of standardization of design across projects by reusing the organizational subsystem components (i.e. of the same supplier) to foster collaboration. Still from a temporary organization perspective, Fernandes et al. (2018) mention that mechanisms are dynamic over time, also existing simultaneously and to varying extents, i.e. enduring and temporary, centralized and decentralized.

Overall, mechanisms for collaboration and coordination may enable improvement of project performance, achieving better communication, integration and coordination of suppliers within the megaproject (Riazi et al., 2019). Although centered on the interfirm relationship level of analysis, the mechanisms can also extend to macro- and intra-organizational levels. From a macro perspective, it can involve mechanisms to collaborate with public bodies or governments (Fernandes et al., 2018; Zhu et al., 2018). From the intra level perspective, Costa, Denis Granja, Fregola, Picchi and Portioli Staudacher (2019), for instance, discuss the organizational 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 – Pinto, Slevin and English (2009) – was focused almost exclusively on project trust, this dimension can be found more frequently as an interface with other dimensions such as governance, procurement or other subcategories of inter-firm collaboration. Project trust enhances a variety of intra-organizational relationships such as project team dynamics, management support, and cross-departmental coordination. Trust can appear and be relevant at intra- and inter-organizational levels. Inter-organizational trust is dependent on intra-organizational 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 & Kamble, 2019).

4.1.3. *Social aspects, communication, and mechanisms*

Socialization and communication play a key role in inter-firm coordination and collaboration. Other than its relation to collaboration and

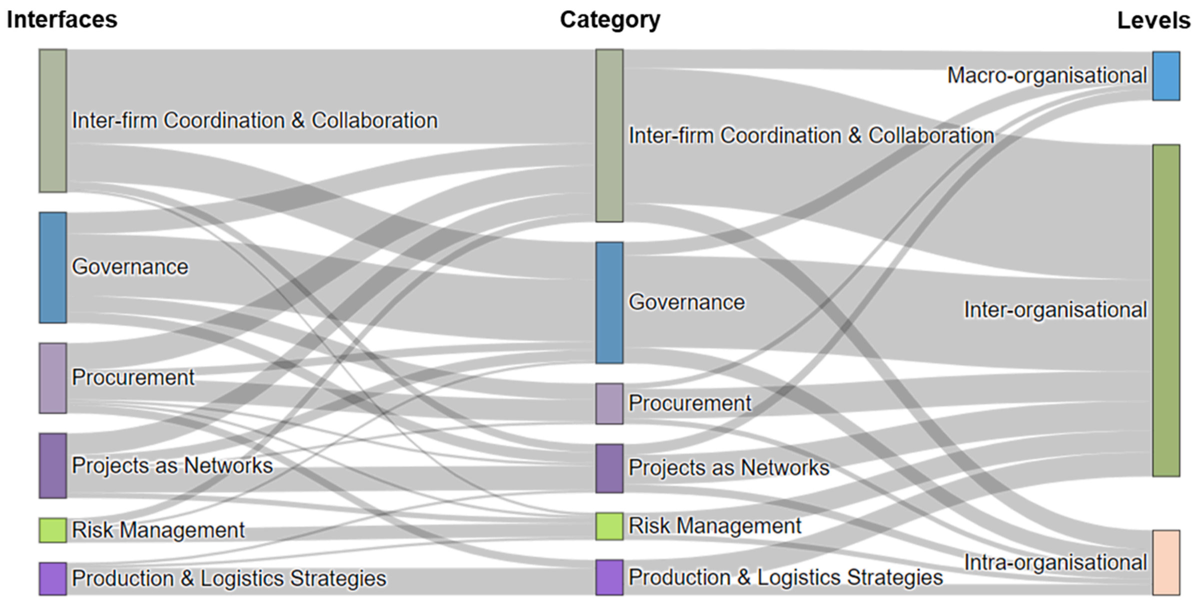


Fig. 2. Sankey diagram: categories, interfaces, and levels.

coordination mechanisms, this dimension also has 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 socialization mechanisms were used to maintain the current level of relational capital.

4.1.4. *Supplier development, integration, and management*

This dimension focused on inter-organizational relationships and has a significant interface with procurement, given its concern with supplier selection as seen in Tchokogué, Nollet and Beaulieu (2017) or Zeng et al. (2019). Supplier development and management identifies how information, processes, teams, and firms are organized to develop further collaboration and integration within the megaproject supply chain. The selection of suppliers and types of partnerships (collaborative and/or relational-oriented) 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). Supplier development and integration may involve macro aspects in complex environments such as the Olympic Games (OG) as there are many ‘external’ actors – such as the OG organizing committee and international federations – that can influence supplier selection (Tchokogué et al., 2017).

4.2. *Governance*

Most project governance research is concerned with inter-firm governance mechanisms implemented in megaprojects. However, it also includes insights into project control and structure and whole governance systems. Appendix G depicts and summarizes the nodes coded with the governance category with the following subcategories: governance mechanisms; project control; project structure; and governance approaches.

4.2.1. *Governance mechanisms*

Governance mechanisms have a significant interface with collaboration and coordination mechanisms, but often transcend those concepts. Kujala et al. (2021), for instance, consider coordination as a dimension of inter-organizational governance citing governance mechanisms 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. Overall, governance mechanisms can reduce opportunistic behaviors, increase awareness of project risk (Jagtap & Kamble, 2015), help deal with project changes (Hetemi, Jerbrant & Mere, 2020), foster cross-disciplinary cooperation and innovation, promote self-monitoring, alignment of goals, and support knowledge integration (Kujala et al., 2021), among other benefits.

4.2.2. *Project control*

Studies of 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 design control systems (Boland et al., 2008). They may focus on either intra- or inter-organizational levels and are comprised of different types of mechanisms including financial, bureaucratic, and socialization modes (Van Marrewijk, 2005). Project control builds a formal process that managers use to influence others towards achieving a goal (Wang et al., 2019). Project control may be related to collaboration based on inter-firm project trust and social exchange norms such as reciprocity, negotiation, and the sharing of information between organizations in the project supply chain (Wang et al., 2019).

4.2.3. *Project structure*

Studies of this subcategory aim to understand the overall structure, arrangement and organization of firms, actors, and other diverse entities in the megaproject environment. Topics of discussion within project structure include, but are not limited to, the centralization and decentralization of control and decision-making (Bouraoui & Lizarralde, 2013; Genus, 1997a), the role of the client within the project (Brady, 2011), and the intra-relationships of direction and empowerment against inter-organizational control and flexibility (Szentes, 2018). Eren (2019) takes into consideration diverse political and social aspects going around the construction of Istanbul’s airport and observes that a government-level organizational structure reduced complexity, risk, and uncertainty and improved inter-organizational compatibility and communication.

4.2.4. Governance approaches

Unlike governance mechanisms, governance approaches refer to whole systems of governance rather than specific mechanisms. According to Bekker (2014), the definition of project governance varies in accordance with the technical level of controlling, monitoring and complying and the institutional level of guidance, decision and responsible citizenship. Additionally, governance approaches differences are influenced by stakeholder complexity rather than project complexity, as they often involve governing an internal supply chain composed of multiple multinational firms and, at the same time, an external network of actors affected by the megaproject. Drawing insights from the project network view, an open systems approach to governance is proposed in which projects are embedded and interwoven with complex institutional environments. This approach shifts attention from a hierarchical supply chain and coordination mechanisms based on simplistic perspectives such as price, to horizontal mechanisms focused on relationships and self-regulation. They advocate extending from a multi-firm temporary view of projects to include the business interests of the actors beyond the project's duration.

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. Procurement provides insights into supplier selection and procurement systems. Appendix H presents the Sankey diagram for procurement, with the following sub-categories: contracts; project alliancing; sustainable, social, and green procurement; and bidding, supplier selection, and systems.

4.3.1. Contracts

The literature on contracts often compares and describes the benefits of different types of contracts. Contracts have an interface with governance as some types can impact the structure of the project in general. Genus (1997b) uses the case of the Channel Tunnel (the railway tunnel connecting England with France) to describe the design and build type of contract adopted and the ensuing problems associated with it including the diverging interests of the client and the contractor, associated with conflicting views on project specifications, monitoring and pricing. Eventually, this situation combined with the non-existing and/or weak client in the initial stages of the project led to goal incongruence, organizational ambiguity, and poor performance.

4.3.2. Project alliancing

Project alliancing (PA) emphasizes integration – the organizational and relationship arrangements of the project – through the early involvement of strategic parties, transparent financials, shared risks and rewards, and collaborative decision-making (Hietajärvi et al., 2017a). It is a relational approach based on multi-party contracts to promote strong collaboration and integration between the organizations of the project (Hietajärvi, Aaltonen & Haapasalo, 2017b). Focused on the inter-firm relations, PA may be an effective strategy for projects with specific 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. (2017b) draw attention to the importance of relational skills and socialization in project alliances, which is needed to interact and cooperate inter-organizationally across the project lifecycle.

4.3.3. Sustainable, social, and green procurement

Green procurement refers to the process whereby organizations procure services and materials able to meet environmental requirements. Sustainable procurement goes beyond the environmental requirements and incorporates social considerations in the procurement process (Uttam & Le Lann Roos, 2015). With a strong association with environmental and social aspects, sustainable procurement may often involve governments, regulatory bodies, and communities. Consequently, this dimension is directly linked to the macro-organizational level of analysis.

4.3.4. Bidding, supplier selection, and procurement systems

This sub-category refers to the operational aspects of supplier selection and procurement systems. Most studies focus on the procurement processes of organizations, while a few pay attention to inter-organizational and dyadic relationships. Studies in this subcategory are mainly concerned with the technical aspects of procurement. However, the bidding process and supplier selection are critical for defining the appropriate supply strategy for the project (Tchokogué et al., 2017) and are typically presented in the literature as interfaces that support other main categories. 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, Qi & Liang, 2018), and enhance the efficiency and performance of related parties (Safa, Shahi, Haas & Hipel, 2017).

4.4. Projects as networks

Project networks draw concepts from complex systems (Kujala et al., 2021) and social networks (Adami & Verschoore, 2018; Pauget & Wald, 2013) to describe behaviors and structures of the multi organizational environment of megaprojects, its suppliers and stakeholders, and their relationships. Adding to the inherent complexity, this category addresses other aspects such as the temporariness of such endeavors (Pauget & Wald, 2013; Ruuska et al., 2009). Appendix I depicts the overall analysis of the project as networks category and the following subcategories: network structures; supply networks; project complexity; and temporary networks.

4.4.1. Network structures

This sub-category is concerned with understanding the overall structure of the project network, including measures such as network size (number of actors), connectivity between the actors, and symmetry of relations between actors (Pauget & Wald, 2013). Network structures provide a holistic analysis of project networks and how they are managed (Ruuska et al., 2009). For Hellgren and Stjernberg (1995), the network structure represents the project process of organizing between actors with different, and often conflicting, rationalities, goals and priorities, and with distinct and dynamic power positions in the overall structure. Network structures help to reveal the dynamics of megaprojects – for individual actors and the whole network – such as complexity levels, governance issues, contractual relationships, and flows of information and goods (Adami & Verschoore, 2018). Network structures may also extend to the macro level of analysis to include communities, governments and other external stakeholders (Yang et al., 2018).

4.4.2. Supply networks

Supply networks differ from traditional hierarchical models in terms of their level of complexity, several same- and inter-tier suppliers supplying to each other, inter- and reverse-tier relationships in a system with nonlinear dynamics (Brintrup et al., 2017). Such models can provide a better understanding of the overall organizational structure and governance formed by owners, operators, sponsors, clients, and suppliers and how such arrangements impact the performance of megaprojects (Denicol et al., 2020). Thürer et al. (2020) present research on China's belt road initiative (BRI) and explore four key aspects of the supply chain: configuration, resilience, sustainability, and cross-border SCM.

4.4.3. Project complexity

Project complexity is presented in varied forms in the literature. According to De Rezende, Blackwell and Pessanha Gonçalves (2018), the field of complexity evolved from disconnected works to more current discussions focused on uncertainty and dynamics to help managers adapt and manage complex projects. They include aspects such as complexity models and systems, performance, uncertainty, design, and innovation. Project complexity is seen as a significant contribution to megaproject failure, causing cost and time overruns (Qazi et al., 2016). However, project complexity appears as a secondary aspect or a characteristic of such endeavors in the megaproject literature. Project complexity is an inherent characteristic of large infrastructure projects that needs to be recognized and managed at intra and inter-organizational levels of the project network (De Rezende et al., 2018).

4.4.4. Temporary networks

Within the megaproject supply chain literature, temporary networks have received more attention as either a background condition or being depicted as a characteristic of large and complex projects. The concept of temporariness embedded in project networks refers to the fact that they exist in a specific structure and only for the duration of a single project (Ruuska et al., 2009). Ruuska et al. (2009) challenge the view that projects are a temporary endeavor with a finite life cycle, advocating instead a new perspective where projects are incorporated in the business interests of actors beyond the lifespan of the project. Nevertheless, temporary networks still provide ground and context for other discussions such as coordination mechanisms (Fernandes et al., 2018), the assembly of project capabilities (Zerjav, Edkins & Davies, 2018), and relationships between its actors and governance (Pauget & Wald, 2013).

4.5. Production and logistics strategies

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

4.5.1. Production strategies

Production strategies refer to approaches commonly used in manufacturing to increase productivity, efficiency, and overall performance including but not limited to just-in-time (JIT) (Walsh et al., 2004), lean manufacturing (Dainty & Brooke, 2004), and quality management (Wu, Yang, Wang & Yuan, 2013). Those strategies tend to focus on intra and inter-organizational levels including a single organization or project with key partners or suppliers. Production approaches bring benefits to manufacturing and have recently been addressed in the megaproject supply chain literature. Among its benefits in large and complex projects, Walsh et al. (2004) use a simulation model based on a case study to show that JIT brings savings in up-front capital, reduction of inventory costs, increased flexibility, and consequently performance improvement.

4.5.2. Third-party logistics (TPL)

From a SCM perspective, TPL aims to rely on specialized third-party actors to manage logistics and coordinate material flows across the supply chain (Le et al., 2020). The construction industry has paid more attention to third-party logistics as a means to deal with the challenging context of higher costs and lower productivity compared to other industries (Ekeskär & Rudberg, 2016). Janné and Rudberg (2022) report a series of positive impacts, such as the minimization of disturbances on site and in the supply chain, reduction of on-site materials, improved utilization of site space, higher productivity, and improved supply chain visibility and planning. Ekeskär and Rudberg (2016) find that establishing an effective interface between the construction site and the supply chain increases productivity, reduces costs and improves utilization of site assets.

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 accomplished by a set of different approaches such as strategic inventory management (Walsh et al., 2004), monitoring and tracking (Nasir et al., 2010), and materials requirement planning (MRP) (Caldas et al., 2015). Effective inventory and materials management can be beneficial for the supply chain. Walsh et al. (2004) suggest the strategic positioning of inventories is an option for owners and contractors, allowing workforce assignment flexibility and eliminating shipment and – as a consequence – construction delays. However, procuring materials in advance generates increased inventory costs and requires up-front capital investment. Nasir et al. (2010) show that inventory management increases productivity and minimizes material loss.

4.6. Risk management

Risk management in the megaproject supply chain has been explored from the perspective of the project and supply chain. Mostly focused on the inter-organizational aspects, risk management has an interface with all the other categories discussed in this review. Appendix K presents the summary of the categories and sub-categories of risk management: project risks; and supply chain risks.

4.6.1. Project risks

Project risk consists of relational and performance risks. In the client-contractor dyad, risk is longitudinal and dynamic and appears in the operational behavior of the project (Jagtap & Kamble, 2015). Methods to manage project risk are well-documented in the literature in various models (Qazi et al., 2016) and processes (Hietajärvi et al., 2017c; Riazi et al., 2019). Project risk management may help identify, monitor (Boateng et al., 2015), and mitigate project risks (Riazi et al., 2019), facilitate tracking and control of project performance, and forge collaboration (Jagtap & 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 – supporting innovation in the development and delivery of large projects, particularly in project alliances where collaboration, knowledge sharing and organizational learning predominate (Hietajärvi et al., 2017c).

4.6.2. Supply chain risks

In this dimension, risk management is concerned with the supply chain issues, such as supply chain configuration, logistics, planning and forecasting, and inventory (Rudolf & Spinler, 2018). As in project risk management, this category includes models and processes to identify, measure, and mitigate risks in 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. The earlier the risks are found, the lower the costs and the greater the opportunities to mitigate them. Therefore, the identification of risks helps to eliminate or 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 advocated 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 & Spinler, 2018).

4.7. Summary of results and managerial practices

Our analysis of the literature through extensive coding enabled the identification of six categories and 21 sub-categories, as presented in the previous sub-sections. The six categories provide the structure for our discussion and reporting of the managerial practices. We define the supply chain as the unit of analysis, identifying and defining its micro, meso, and macro levels. The micro, meso, and macro level perspectives have important practical implications. Table 2 presents the main strategies and practices found in the literature and connects them to the respective level. The table 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, following the findings of the SLR.

At the microlevel, the focus is on specific organizations, teams, or individuals. Therefore, the boundaries of the studies are the organization itself. Although it can be embedded in and influenced by a project supply chain, at the micro level less attention is given to inter-organizational relationships and connections beyond the focal company. Van Marrewijk 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, Ruuska et al. (2009) include an intra-organizational dimension in a framework exploring the concept of 'distance' between actors in large projects. The individual firm dimension includes characteristics such as lack of capabilities, systems and processes, and knowledge of local project requirements. At the meso level the focus shifts to inter-firm relationships and the extended supply chain, to provide a broader understanding of the megaproject and the interdependencies impacting the project at different levels. Supply chain studies often address this dimension, but there are opportunities to explore the other levels, as seen in many examples discussed previously.

Table 2
Strategies and practices for performance improvement in the management of megaproject supply chains.

Level of Analysis	Inter-firm Coordination and Collaboration	Governance	Procurement	Projects as Networks	Production and Logistics	Risk Management
Macro Communities, governments, and political and social systems	• Collaboration standards (Chakkol et al., 2018)	• Government hands-on management (Eren, 2019) • Decentralized decision making (w/ external stakeholders) (Bouraoui & Lizarralde, 2013) • Benchmarking (Yun et al., 2016)	• Competitive dialog procedure (CDP) (Uttam & Le Lann Roos, 2015) • Social procurement (Loosemore, 2016)	• Supply chain configuration (Thürer et al., 2020) • Knowledge and coordination routines in temporary organizations (van Fenema et al., 2016)		
Meso Inter-organizational, dyadic relations, and the extended supply chain	• Cost-sharing, purchase price, and purchase quantity (Shi et al., 2018; Zeng et al., 2019) • Early involvement of key participants (Hall, Algiers, & Levitt, 2018) • Information sharing (Wang et al., 2019) • Joint agreed goals (Riazi et al., 2019) • Development of relational competence (Pauget & Wald, 2013)	• Alignment of goals (Hetemi et al., 2020; Kujala et al., 2021) • Decentralization of control and decision making (Genus, 1997a; Van Marrewijk, 2005) • Definition of roles and responsibilities (Kujala et al., 2021) • Monitoring and performance measurement (Kujala et al., 2021; Steen, Ford, & Verreynne, 2017; Wood, 2017) • Open systems view (Ruuska et al., 2011)	• Multi-party contracts (Brahm & Tarziján, 2015) • Cost-plus contracts (Lavikka et al., 2015) • Project alliancing approach (Hietajärvi et al., 2017a; Walker & Jacobsson, 2014; Young et al., 2018)	• Capability mechanisms for temporary settings (Zerjav et al., 2018) • Flows of information and goods (Adami & Verschoore, 2018) • Network attributes understanding (Hellgren & Stjernberg, 1995; Ruuska et al., 2009) • Network perspective for the supply chain (Brintrup et al., 2017)	• Just-in-time (JIT) / Lean manufacturing (Dainty & Brooke, 2004; Walsh et al., 2004) • Quality management (Gaudenzi & Qazi, 2020; Wu et al., 2013) • TPL implementation (Ekeskär & Rudberg, 2016; Janné & Rudberg, 2022; 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 & Spinler, 2018)
Micro Intra-organizational relationships	• Management support (Pinto et al., 2009) • Relationship-oriented management (Klijn, Edelenbos, Kort & van Twist, 2008) • Reutilisation of subsystem components (Artto & Turkulainen, 2018)	• Control systems (Boland et al., 2008) • Critical path optimization and measurement (Elizabeth & Sujatha, 2013, 2015; Wood, 2017)	• Robust supplier selection processes (Riazi et al., 2019; Tchokogué et al., 2017) • Procurement systems (Kovacs & Paganelli, 2003; Safa et al., 2017)	• Cognitive mapping (Edkins, Kurul, Maytorena-Sanchez, & Rintala, 2007)	• Digitalization (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)

The macro-organizational level expands the megaproject supply chain to include external stakeholders (Yang et al., 2018), socio-political aspects (Eren, 2019), industry-wide factors (Yun, Choi, Oliveira, Mulva & Kang, 2016), and temporary and permanent clusters of actors within a network (Pauget & Wald, 2013). We expand the rationale and emphasize the managerial implications regarding inter-firm collaboration and the network perspective, which are structured by the multi-level perspective. The inter-firm collaboration is strongly connected to coordination, procurement, and governance mechanisms. Many mechanisms of governance such as alignment of goals (Hetemi et al., 2020) and decentralization of decision-making (Bouraoui & Lizarralde, 2013) aim to forge improved collaboration and coordination (Kujala et al., 2021) among actors of the supply chain. Mechanisms of collaboration and coordination – such as joint agreed goals and information sharing – may comprise whole systems of governance. Such relationships make it even harder to distinguish governance mechanisms from collaboration mechanisms, as they often work in tandem. Similarly, procurement practices – such as multi-party contracts (Brahm & Tarziján, 2015) and project alliancing (Walker & Jacobsson, 2014) – aim to increase collaboration and may provide overall guidance, influencing the governance structures of the project. Therefore, project managers and researchers interested in SCM performance improvement may promote and implement governance approaches and procurement practices to foster inter-firm collaboration and coordination.

5. Discussion – Megaproject Supply Chain framework

Our analysis of categories and sub-categories summarized the current literature, revealing significant theoretical and practical fragmentation, including a variety of terminologies and strategies. The strategies identified extend from specific intra-organizational processes (Elizabeth & Sujatha, 2015) and focus on individuals and teams (Klijn et al., 2008), to governance approaches (Eren, 2019) and network perspectives (Brintrup et al., 2017). Informed by our results, we critically discuss the implications and present a multi-level Megaproject Supply Chain (MSC) framework that provides the structure for our future research avenues. The MSC framework accounts for and incorporates many of the theoretical lenses found, reviewed, and categorized during the SLR process, as well as the dynamics of temporary and permanent components of the megaproject supply chain. It builds on the review process and exemplifies the components of the megaproject supply chain and its complex relationships across the nested levels.

The MSC framework accounts for the nested relationships found within a multi-level megaproject supply chain. In the multi-level nested arrangement proposed by Hitt, Beamish, Jackson and Mathieu (2007), the micro level focuses on psychological and sociological bases (individuals and teams), the meso level considers relational and network issues, and the macro level involves political, economic, and societal dynamics. This view, however, has received different interpretations by other authors and has been adapted accordingly. Paruchuri, Perry-Smith, Chattopadhyay and Shaw (2018) refers to intra-individual, individual, team, project group, divisions, business units, and organizations as examples of different levels of analysis and shows that the level of conceptualization depends on the selected unit of analysis. From the perspective of evolutionary economics, the micro level can refer to individual organizations, behavioral routines, and individual carriers of the system's rules; the meso level is a population of the micro components, forming a system, and the macro level is a system formed by the meso level systems and individual (micro) elements as a whole (Dopfer, 2012, 2004). We build on those views and propose a framework to define the levels of analysis of the megaproject supply chain.

In the MSC framework, we propose three main levels (micro, meso, macro), as well as two hybrid levels: the meso-micro and meso-macro levels, as shown in Fig. 3. During the analysis, we found that the boundaries between the three main levels are not always clearly delimited and some relationships in the megaproject supply chain might lie in a 'gray area' between two levels. By incorporating the hybrid levels in the MSC framework we seek to provide a more comprehensive and accurate representation of the composition and relationships found in megaproject supply chains.

The MSC framework illustrates the complexity of the megaproject supply chain and its components, as well as the distinct pockets of performance. The micro level identifies permanent organizations that will continue to exist after the megaproject is terminated, such as suppliers that supply materials for the megaproject, as well as the teams and individuals that form those organizations. The temporary structures refer to arm's length bodies or new joint ventures (JVs) specifically created for the megaproject and the teams and individuals that comprise them. At this level, the distinction between permanent and temporary layers is easier to identify, although the two layers may be combined. For example, a permanent supplier can form a temporary structure or team at its own headquarters that is dedicated to the megaproject's businesses and operations. The hybrid level between the micro and meso levels focuses on dyadic inter-organizational relationships formed by two different organizations – such as buyer-supplier, client-consultant, and system integrators tier 1-tier 2 suppliers.

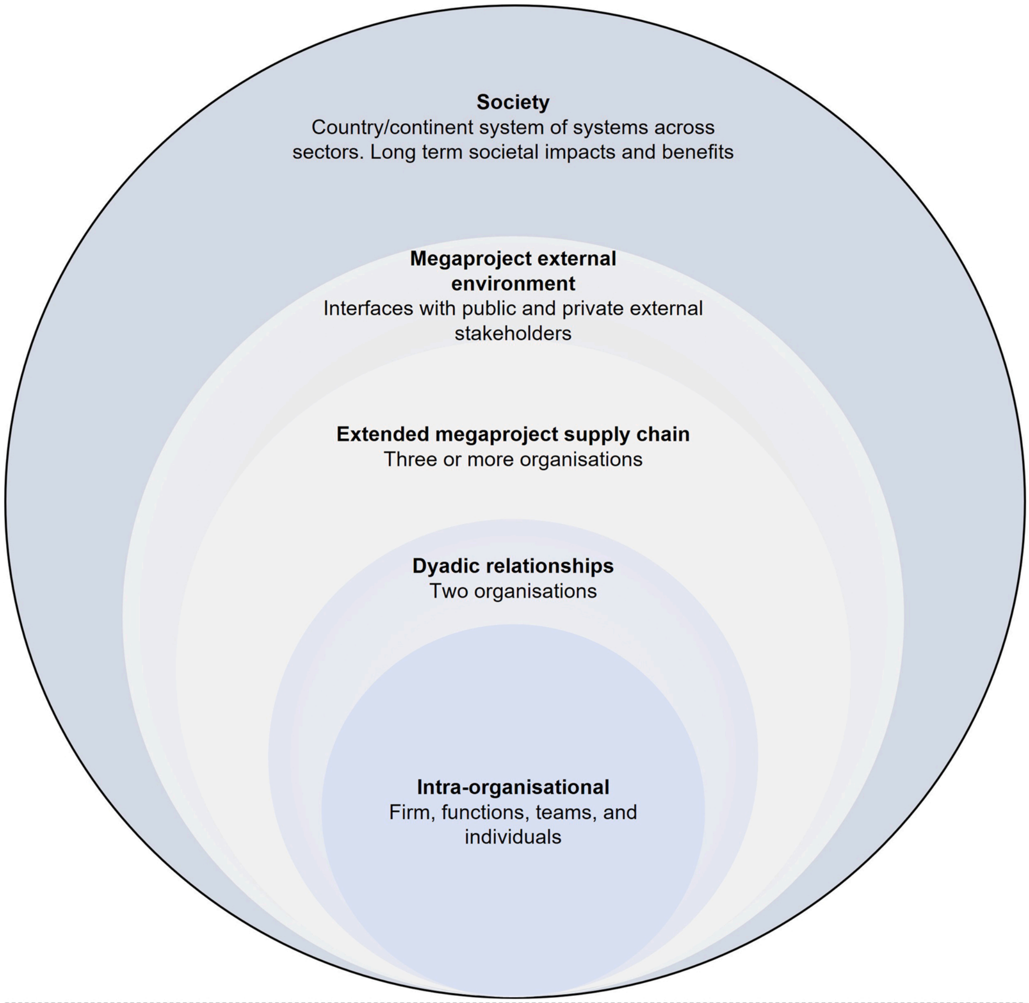
At the meso level, the permanent and temporary layers extend through the megaproject supply chain beyond dyadic relationships. The permanent layer includes organizations, such as suppliers, that will remain functioning after the megaproject terminates. Then, the meso-macro level extends outwards to relationships and components of the megaproject with the macro (or external) environment. The government, for instance, as an owner of the megaproject operates between the two levels (meso and macro), as it is part of the megaproject organization, while at the same time having strong ties with the external macro environment. Another example can be when communities that are directly impacted by the megaproject or activist groups engaging directly with the megaproject organization.

The macro level includes stakeholders, agents, and components in society that are not directly involved in the megaproject but may impact and influence it. In complex projects, temporary and permanent aspects are often difficult to grasp as many systems can be involved in a system of systems (Brady & Davies, 2014; Davies & Mackenzie, 2014). Components of the macro environment include the society, the public sector or state, and other country and continent-wide infrastructure systems with long-term societal impacts. Examples include the UK's rail and underground structure in the High Speed 2 project or the current transportation routes affected by the BRI. The societal environment is the highest level of analysis in the nested arrangement of the megaproject supply chain and concludes the five levels proposed in the MSC framework. By defining the levels and their connections, the framework identifies the complex and networked components, relationships and external environment shaping the organization of the megaproject supply chain.

5.1. Research agenda

Informed by our SLR categories and based on the MSC framework, we discuss opportunities, risks, and contributions for each one of the levels and develop a research agenda. The megaproject literature is often concerned with the dyadic relationships (e.g. owner-contractor) and rarely considers the management of the extended supply chain. In the supply chain management literature, the emphasis is on mass production following a Make-to-Stock production strategy, while the Engineering-to-Order (ETO) perspective is the approach that most resonates with the industrial strategy of projects (Cannas & Gosling, 2021; Gosling et al., 2009). Yet, the ETO literature is largely silent regarding the characteristics of megaprojects, particularly scale, complexity levels, the temporary and permanent configurations, and the often-public nature of such endeavors. Therefore, our research agenda aims to inspire future researchers to advance the management of supply chains in the multi-level context of megaprojects.

The network perspectives enable a multi-level analysis of flows and



Levels	Components
Macro	Society, state (public factor), infrastructure systems
Meso-macro	Government (owner), industry, affected communities, activist groups
Meso	Extended supply chain (contractors, integrators, clients, delivery partners, etc.)
Meso-micro	Buyer-supplier, client-consultant, tier 1 system integrator-tier 2 supplier
Micro	Arm's-length bodies, suppliers, project/supplier's teams & individuals

Fig. 3. The multi-level Megaproject Supply Chain (MSC) framework.

relationships and provide a theoretical lens for the other categories (Provan, Fish, & Sydow, 2007). The network structures and attributes of a complex system, for example, may help to identify misaligned objectives and unclear roles and responsibilities of actors, shaping inter-firm collaboration and governance mechanisms and approaches (Ruuska et al., 2009). Such studies improve our understanding of how the temporary nature of project networks is coordinated and influenced by the macro-environment. Procurement and inter-firm coordination processes depend on networked flows of information, products, and services (Adami & Verschoore, 2018). Overall, network approaches provide a useful theoretical lens that view megaprojects, their supply chain, and their macro-environment as a complex and networked endeavor, formed by clusters of different agents and with multiple temporalities (Brintrup et al., 2017; Denicol et al., 2020; Hellgren & Stjernberg, 1995). We suggest four themes as future avenues to advance supply chain management in megaprojects through multi-level explorations: (i) Supply Chain Structure: Permanent vs Temporary, (ii) Strategic Procurement and Commercial, (iii) Supply Chain Design: Standardization vs Customization, (iv) Supply Chain Governance: Collaboration and Coordination.

5.1.1. *Supply Chain Structure – Permanent vs Temporary*

The focal organizations in charge of megaprojects are often responsible for the last level of integration and coordination. Yet, such efforts are a result of the structural complexity of the megaproject being delivered by the supply chain (Denicol et al., 2021). In future, researchers might investigate how the intra-organizational structures of the client organization should reflect the complexity of the different systems and sub-systems across the supply chain. Inspired by well-established literature on modularity and platforms (Baldwin & Clark, 2000; Gawer & Cusumano, 2014), researchers might also explore how the enterprise architecture should mirror the product structure, particularly considering that such organizations are often structured on a temporary basis, just for the duration of the project. Researchers might be interested in investigating the horizontal and vertical integration strategies adopted by the focal firm, exploring the project characteristics that might influence the formation of alliances with different supply chain partners.

Projects as networks provides a promising perspective to understand the complexity of megaproject supply chains (Sydow, 2022). However, topics such as project complexity and temporary networks tend to be used as a descriptive characteristic or a secondary aspect of the supply chain of megaprojects. Research might bring to the fore a focus on temporary aspects and understand the relationships between clusters of permanent suppliers and supply chains, and temporary project organizations. Research might consider the implications of abandoning the temporary view of multi-firm projects, as suggested by Ruuska et al. (2011). A network approach might provide a powerful lens for multi-level research because it accounts for flows and relationships at individual and macro levels, providing important insights into the roles, responsibilities, and capabilities of the actors of the supply chain.

5.1.2. Strategic Procurement and Commercial

Temporary client organisations delivering megaprojects are increasingly focused on procurement and commercial interfaces. In permanent environments, there is stability and an environment conducive to continuous learning through economies of repetition. How do clients rely on contracts and procurement to incentivise the supply chain to react in a short period of time? The ecosystem literature (Jacobides, Cennamo, & Gawer, 2018; Shipilov & Gawer, 2020) is more advanced in permanent, mass production sectors, and less clear on the operationalisation in more temporary, yet long environments, such as megaprojects. The SCM literature could be enhanced by investigating how permanent and temporary clients create a megaproject ecosystem. How could the longevity of such programmes be reconciled with specific requirements of multiple phases to create a client-driven ecosystem?

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

5.1.3. Supply Chain Design: Standardization vs Customization

Megaproject supply chains are characterised by fragmentation and different levels of complexity. In previous megaprojects (Denicol, 2020), such as the London 2012 Olympics, different approaches were used to deal with supply chains oriented to deliver standard products and other parts of the program where suppliers were collaborating to deliver more customized one-off products/solutions. The decomposition of the supply chain might provide a more granular understanding to inform decision making strategies, breaking down complexity and mitigating risks (Browning, 2001). Researchers could investigate the degrees of standardization and customization of megaproject supply chains and how strategies from more advanced industrial sectors might provide insights to deal with multiple temporalities and degrees of complexity. Researchers might be inspired to investigate the structural features of markets and industrial trades that create such complexity. How could clients investigate different supply chain structures within the megaprojects and suggest procurement strategies based on modularity and standardization?

Regarding productivity, researchers might 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 for its low productivity levels when compared. Considering the low productivity of the construction industry, researchers might be interested in cross-industry benchmarking studies (i.e. manufacturing) to enhance productivity levels. Since extant literature on risk management focuses almost exclusively on intra and inter-organizational levels, future research might adopt an industry-wide comparative approach to evaluate alternatives and consider what may be adapted to study megaprojects (Rudolf & Spinler, 2018).

5.1.4. Supply Chain Governance – Collaboration and Coordination

There are barriers that may undermine inter-firm collaboration. Costa et al. (2019) divide them into cultural, organizational, and industry. Industry barriers, specifically, have not been fully explored as they lie outside the boundaries of the organizations and 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, and other organizations. Extant literature has identified types of mechanisms used to achieve coordination and collaboration between firms of the project, but rarely considered how those firms develop capabilities and learn to collaborate with other organizations in megaprojects (Denicol & Davies, 2022). Researchers might consider how integration can be achieved at multiple levels (Tee, Davies, & Whyte, 2019), and how each system produced by a megaproject (e.g. Crossrail) (Muruganandan, Davies, Denicol & Whyte, 2022) integrates with other systems at the macro level (i.e. System of systems). Processual and longitudinal case-study research may provide interesting insights into how firms develop such capabilities (Chakkol et al., 2018). Research on procurement might explore coordination mechanisms with different types of contracts, such as dyadic or multi-party contracts, and project delivery strategies (Ju, Ding & Skibniewski, 2017).

Research on megaproject governance mechanisms may benefit from a network perspective to understand relationships between contractors, subcontractors and other supplier tiers (Ruuska et al., 2009) and extended to address the macro level by, for instance, exploring mechanisms to monitor external stakeholders, and overall socio-cultural and economic aspects and how to operationalize them (Kujala et al., 2021). Governance approaches may benefit from more in-depth case studies to examine their designs and effectiveness and suggest new approaches (Ruuska et al., 2011; von Danwitz, 2018). Intra-organizational research could explore the multi-level of the MSC framework to measure the impacts and effects of megaproject governance on individual contractors, subcontractors, or other suppliers from diverse tiers.

6. Conclusion

In this paper, we provided a comprehensive definition of the multi-level configuration of megaproject supply chains, 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 common ground so that research can advance in promising new directions. The MSC framework and the discussion provided in this paper may help researchers understand units of analysis, concepts, and different theoretical lenses. By defining a common language for levels, strategies, and practices, this research identifies different pathways for understanding the configuration and performance in megaproject supply chains among PM and OM communities of scholars.

Our SLR consolidated the overall concepts, terminologies, and perspectives regarding strategies for the management of supply chains in megaprojects. 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-organizational – based on 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 suggested. The MSC framework unpacks the megaproject supply chain and may help identify interesting research questions, define the level of analysis, and encourage the use of multi-level approaches.

Our study has implications for practitioners, as the categories are clearly defined, and the discussion describes outcomes, results, and benefits from the practical application of the strategies to manage supply chains in megaprojects. The analysis and framework can provide managers with a comprehensive picture and understanding of the key components and relationships in the entire megaproject supply chain. In this context, the role of systems thinking is essential to understand megaproject supply chains beyond the client-contractor dyad as a complex and networked endeavor, formed by clusters of different agents and with multiple temporalities. For instance, the identification of the need and implementation of systemic governance approaches and procurement practices to foster inter-firm collaboration and coordination across multiple levels and boundaries. The study is limited by our strategy of excluding gray literature, mainly due to the challenges in consistency to operationalize the search protocols. It may also present some limitations due to the search criteria delimited by the authors, leaving out of the analysis studies that are potentially relevant to the research, even though the process for the selection of the terms was broad and extensive and the SLR protocols were followed strictly. Finally, we acknowledge the value and meaningful practical considerations that some reports classified as gray literature might provide, particularly from influential think tanks and intergovernmental organizations.

Appendix A. – Systematic literature review protocol

Search Strategy Protocol		
Conceptual Framework	The performance of supply chain in project-based industries, especially in complex inter-organizational environments.	
Context	Complex, temporary organizations, 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 used to manage megaproject supply chains?	
Review Strategy	() Aggregative	(X) Configurative
Search Criteria	Inclusion criteria	Exclusion criteria
	Papers related to megaprojects, large capital projects, complex environments, etc.	Papers not related to megaprojects, conference papers, other non-peer reviewed sources (books, reports, etc.), documents not in English.
Search terms	As seen in Appendix B.	
Search sources		
Databases:	Scopus Web of Science	

Appendix B. – SLR terms

Term	Class	Class Description	Synonyms
1	1	Mega / Major	"Mega-project*", "Mega-program*", "Mega infrastructure*", "Mega construction*", "Mega system*", "Mega capital project*", "Mega inter-organi?ation*", "Major project*", "Major program*", "Major infrastructure*", "Major construction*", "Major engineering*", "Major system*", "Major capital project*", "Major inter-organi?ation*", "Major organi?ation*"
1	2	Large	"Large scale project*", "Large scale program*", "Large scale infrastructure*", "Larga scale construction*", "Large scale engineering*", "Large scale system*", "Large scale capital project*", "Large scale inter-organi?ation*", "Large scale organi?ation*", "Large scale urban development*", "Large project*", "Large program*", "Large infrastructure*", "Large construction*", "Large engineering*", "Large system*", "Large capital project*", "Large inter-organi?ation*", "Large organi?ation*", "Large technical system*"
1	3	Capital	"Capital project*", "Capital program*", "Capital infrasctructure project*", "Capital construction*", "Capital engineering*", "Capital System*", "Complex project*", "Complex program*"
1	4	Complex	"Complex infrastructure project*", "Complex construction*", "Complex engineering*", "Complex system*", "Complex capital project*", "Complex inter-organi?ation*", "Complex organi?ation*", "Complex products and systems*"
1	5	Macro	"Macro project*", "Macro program*", "Macro infrastructure*", "Macro construction*", "Macro engineering*", "Macro system*", "Macro capital project*", "Macro inter-organi?ation*", "Macro organi?ation*"
1	6	Tera / Giant	"Tera project*", "Tera program*", "Giga project*", "Giga program*", "Giant Project*", "Giant Program*"
1	7	Infrastructure	"Infrastructure project*", "Infrastructure program*", "Infrastructure system*", "Infrastructure organi?ation*"
1	8	System / project	"System of system*", "Grand scale project*", "Unique project*", "Global project*", "Monumental project*", "High rise project*", "High rise construction project*", "Transformational project*", "Public works project*"
1	9	Temporary	"Temporary*", "One off*", "One of a kind*"
1	10	Production Strategy	"Engineer to order*", "Buil? to order*", "Make to order*"
2	1	Supply Chain	"Supplier Base*", "Supplier Management*", "Supplier Network*", "Supply Base*", "Supply Chain*", "Supply Management*", "Supply Market*", "Supply Network*"
2	2	Inter / Multi	"Inter-firm*", "Inter-organi?ation*", "Multi-firm*", "Multi-organization*"
2	3	Chain	"Delivery Chain*", "Delivery model*", "Demand Chain*", "Value Chain*", "Value System*"
2	4	Network	"Project network*", "Value Network*"

Appendix C. – Search results

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**

Appendix D. – List of selected papers

Title	Journal	Author	Year
Design and implementation in major investments - A project network approach	Scandinavian Journal of Management	Hellgren, B.; Stjernberg, T.	1995
Unstructuring incompetence: Problems of contracting, trust and the development of the channel tunnel	Technology Analysis and Strategic Management	Genus, A.	1997
Managing large-scale technology and inter-organizational relations: The case of the Channel Tunnel	Research Policy	Genus, A.	1997
A planning and management infrastructure for large, complex, distributed projects - Beyond ERP and SCM	Computers in Industry	Kovacs, G. L.; Paganelli, P.	2003
Towards improved construction waste minimisation: a need for improved supply chain integration?	Structural Survey	Dainty, A. R. J.; Brooke, R. J.	2004
Strategic positioning of inventory to match demand in a capital projects supply chain	Journal of Construction Engineering and Management	Walsh, K. D.; Hershauer, J. C.; Tommelein, I. D.; Walsh, T. A.	2004
Innovation in construction: a sociology of technology approach	Building Research and Information	Harty, C.	2005
Private sector consortia working for a public sector client - Factors that build successful relationships: Lessons from the UK	European Management Journal	Jost, G.; Dawson, M.; Shaw, D.	2005
Strategies of cooperation: Control and commitment in mega-projects	Management	Van Marrewijk, A.	2005
The application of cognitive mapping methodologies in project management research	International Journal of Project Management	Edkins, A. J.; Kurul, E.; Maytorena-Sanchez, E.; Rintala, K.	2007
Measuring performance within the supply chain of a large scale project	Supply Chain Management	Wickramatillake, C. D.; Koh, S. C. L.; Gunasekaran, A.; Arunachalam, S.	2007
Designing management control in hybrid organizations: The role of path creation and morphogenesis	Accounting, Organizations and Society	Boland Jr., R. J.; Sharma, A. K.; Afonso, P. S.	2008
Facing management choices: An analysis of managerial choices in 18 complex environmental public-private partnership projects	International Review of Administrative Sciences	Klijn, E.-H.; Edelenbos, J.; Kort, M.; van Twist, M.	2008
Problems causing delays in major construction projects in Thailand	Construction Management and Economics	Toor, S.-U.-R.; Ogunlana, S.	2008
Trust in projects: An empirical assessment of owner/contractor relationships	International Journal of Project Management	Pinto, J. K.; Slevin, D. P.; English, B.	2009
Evaluating project robustness through the lens of the business model	International Journal of Innovation and Technology Management	Reginato, J. M.	2009
Dimensions of distance in a project network: Exploring Olkiluoto 3 nuclear power plant project	International Journal of Project Management	Ruuska, I.; Artto, K.; Aaltonen, K.; Lehtonen, P.	2009
Supplier integration in complex delivery projects: Comparison between different buyer-supplier relationships	International Journal of Project Management	Martinsuo, M.; Ahola, T.	2010
An implementation model for automated construction materials tracking and locating	Canadian Journal of Civil Engineering	Nasir, H.; Haas, C. T.; Young, D. A.; Razavi, S. N.; Caldas, C.; Goodrum, P.	2010
Creating and sustaining a supply network to deliver routine and complex one-off airport infrastructure projects	International Journal of Innovation and Technology Management	Brady, T.	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	Ruuska, I.; Ahola, T.; Artto, K.; Locatelli, G.; Mancini, M.	2011
Centralized decision making, users' participation and satisfaction in post-disaster reconstruction: The case of Tunisia	International Journal of Disaster Resilience in the Built Environment	Bouraoui, D.; Lizarralde, G.	2013
Fuzzy critical path problem for project network	International Journal of Pure and Applied Mathematics	Elizabeth, S.; Sujatha, L.	2013
Relational competence in complex temporary organizations: The case of a French hospital construction project network	International Journal of Project Management	Pauget, B.; Wald, A.	2013
Macro quality chain management and coordination optimization research	Journal of Software	Wu, Y.; Yang, Y.; Wang, Z.; Yuan, J.	2013
Project governance: "schools of thought"	South African Journal of Economic and Management Sciences	Bekker, M. C.	2014
An integrated approach to implement Project Management Information Systems within the Extended Enterprise	International Journal of Project Management	Braglia, M.; Frosolini, M.	2014
A rationale for alliancing within a public-private partnership	Engineering, Construction and Architectural Management	Walker, D.; Jacobsson, M.	2014
An Analytical Network Process model for risks prioritization in megaprojects	International Journal of Project Management	Boateng, P.; Chen, Z.; Ogunlana, S. O.	2015
Does complexity and prior interactions affect project procurement? Evidence from mining mega-projects	International Journal of Project Management	Brahm, F.; Tarziján, J.	2015
Materials Management Practices in the Construction Industry	Practice Periodical on Structural Design and Construction	Caldas, C. H.; Menches, C. L.; Reyes, P. M.; Navarro, L.; Vargas, D. M.	2015
Performance measurement and the prediction of capital project failure	International Journal of Project Management	Chen, H. L.	2015

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Title	Journal	Author	Year
Project scheduling method using triangular intuitionistic fuzzy numbers and triangular fuzzy numbers	Applied Mathematical Sciences	Elizabeth, S.; Sujatha, L.	2015
Developing routines in large inter-organisational projects: A case study of an infrastructure megaproject	Construction Economics and Building	Eriksson, T.	2015
Evaluating the modus operandi of construction supply chains using organization control theory	International Journal of Construction Supply Chain Management	Jagtap, M.; Kamble, S.	2015
Coordinating collaboration in contractually different complex construction projects	Supply Chain Management	Lavikka, R. H.; Smeds, R.; Jaatinen, M.	2015
Status quo and open challenges in vision-based sensing and tracking of temporary resources on infrastructure construction sites	Advanced Engineering Informatics	Teizer, J.	2015
Competitive dialog procedure for sustainable public procurement	Journal of Cleaner Production	Uttam, K.; Le Lann Roos, C.	2015
Third-party logistics in construction: the case of a large hospital project	Construction Management and Economics	Ekeskar, A.; Rudberg, M.	2016
Social procurement in UK construction projects	International Journal of Project Management	Loosemore, M.	2016
Project Complexity and Risk Management (ProCRiM): Towards modeling project complexity driven risk paths in construction projects	International Journal of Project Management	Qazi, A.; Quigley, J.; Dickson, A.; Kirytopoulos, K.	2016
Stability and reconstruction operations as mega projects: Drivers of temporary network effectiveness	International Journal of Project Management	van Fenema, P. C.; Rietjens, S.; van Baalen, P.	2016
Measuring project management inputs throughout capital project delivery	International Journal of Project Management	Yun, S.; Choi, J.; Oliveira, D. P.; Mulva, S. P.; Kang, Y.	2016
Collaborative Management of Complex Major Construction Projects: AnyLogic-Based Simulation Modelling	Discrete Dynamics in Nature and Society	Zhao, N.; An, S.	2016
Supply Networks as Complex Systems: A Network-Science-Based Characterization	IEEE Systems Journal	Brintrup, A.; Wang, Y.; Tiwari, A.	2017
Opportunity management in large projects: A case study of an infrastructure alliance project	Construction Innovation	Hietajärvi, A.-M.; Aaltonen, K.; Haapasalo, H.	2017
Managing integration in infrastructure alliance projects Dynamics of integration mechanisms	International Journal of Managing Projects in Business	Hietajärvi, A.-M.; Aaltonen, K.; Haapasalo, H.	2017
What is project alliance capability?	International Journal of Managing Projects in Business	Hietajärvi, A.-M.; Aaltonen, K.; Haapasalo, H.	2017
Optimization strategies to eliminate interface conflicts in complex supply chains of construction projects	Journal of Civil Engineering and Management	Ju, Q.; Ding, L.; Skibniewski, M. J.	2017
Optimization for the Integrated Operations in an Uncertain Construction Supply Chain	IEEE Transactions on Engineering Management	Liu, Q.; Xu, J.; Qin, F.	2017
Construction contract management using value packaging systems	International Journal of Construction Management	Safa, M.; Shahi, A.; Haas, C. T.; Hipel, K. W.	2017
Symbols, Sublimes, Solutions, and Problems: A Garbage Can Model of Megaprojects	Project Management Journal	Steen, J.; Ford, J. A.; Verreynne, M.-L.	2017
Supply management for major sport events: The case of the 2010 Vancouver Olympic Games	Canadian Journal of Administrative Sciences	Tchokogué, A.; Nollet, J.; Beaulieu, L.	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	Wood, D. A.	2017
Creating relational capital through socialization in project alliances	International Journal of Operations and Production Management	Aaltonen, K.; Turkulainen, V.	2018
Implications of Network Relations for the Governance of Complex Projects	Project Management Journal	Adami, V. S.; Verschoore, J. R.	2018
It takes two to tango: Product-organization interdependence in managing major projects	International Journal of Operations and Production Management	Artto, K.; Turkulainen, V.	2018
Formalisation of selection of contract-organizational project delivery strategy	Eastern-European Journal of Enterprise Technologies	Bugrov, O.; Bugrova, O.	2018
Digital transformation of requirements in the industry 4.0: case of naval platforms	DYNA	Cerezo-Narvaez, A.; Otero-Mateo, M.; Rodriguez-Pecci, F.; Pastor-Fernandez, A.	2018
The governance of collaboration in complex projects	International Journal of Operations and Production Management	Chakkol, M.; Selviaridis, K.; Finne, M.	2018
Research Focuses, Trends, and Major Findings on Project Complexity: A Bibliometric Network Analysis of 50 Years of Project Complexity Research	Project Management Journal	De Rezende, L. B.; Blackwell, P.; Pessanha Gonçalves, M. D.	2018
Coordination in temporary organizations: Formal and informal mechanisms at the 2016 Olympics	International Journal of Operations and Production Management	Fernandes, A.; Spring, M.; Tarafdar, M.	2018
Identifying the Role of Supply Chain Integration Practices in the Adoption of Systemic Innovations	Journal of Management in Engineering	Hall, D. M.; Algiers, A.; Levitt, R. E.	2018
Key risks in the supply chain of large scale engineering and construction projects	Supply Chain Management	Rudolf, C. A.; Spinler, S.	2018

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Title	Journal	Author	Year
Cooperative Evolutionary Game and Applications in Construction Supplier Tendency	Complexity	Shi, Q.; Zhu, J.; Li, Q.	2018
Reinforcing cycles involving inter- and intraorganizational paradoxical tensions when managing large construction projects	Construction Management and Economics	Szentes, H.	2018
Tension in a value co-creation context: A network case study	Industrial Marketing Management	Tóth, Z.; Peters, L. D.; Pressey, A.; Johnston, W. J.	2018
Organizing inter-firm project governance - a contextual model for empirical investigation	International Journal of Managing Projects in Business	von Danwitz, S.	2018
Organizational Citizenship Behavior in Construction Megaprojects	Journal of Management in Engineering	Yang, D.; He, Q.; Cui, Q.; Hsu, S.-C.	2018
Project capabilities for operational outcomes in inter-organisational settings: The case of London Heathrow Terminal 2	International Journal of Project Management	Zerjav, V.; Edkins, A.; Davies, A.	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	Zhang, J.; Qi, X.; Liang, C.	2018
Contractor cooperation mechanism and evolution of the green supply chain in mega projects	Sustainability (Switzerland)	Zhu, J.; Fang, M.; Shi, Q.; Wang, P.; Li, Q.	2018
What makes an alliance an alliance	Journal of Modern Project Management	Young, B.; Hosseini, A.; Klakegg, O. J.; Laedre, O.	2018
Understanding Relative Importance of Barriers to Improving the Customer-Supplier Relationship within Construction Supply Chains Using DEMATEL Technique	Journal of Management in Engineering	Costa, F.; Denis Granja, A.; Fregola, A.; Picchi, F.; Portioli Staudacher, A.	2019
Top government hands-on megaproject management: the case of Istanbul's grand airport	International Journal of Managing Projects in Business	Eren, F.	2019
Applying a longitudinal tracer methodology to evaluate complex interventions in complex settings	European Journal of Work and Organizational Psychology	Fuller, P.; Randall, R.; Dainty, A.; Haslam, R.; Gibb, A.	2019
An empirical assessment of relational contracting model for supply chain of construction projects	International Journal of Managing Projects in Business	Jagtap, M.; Kamble, S.	2019
Collaborative supply chain management (SCM) tools for improved teamwork in construction projects	International Journal of Supply Chain Management	Riazi, S. R. M.; Nawi, M. N. M.; Salleh, N. A.; Ahmad, M. A.	2019
Impact of Control and Trust on Megaproject Success: The Mediating Role of Social Exchange Norms	Advances in Civil Engineering	Wang, D.; Fang, S.; Fu, H.	2019
Incentive Mechanisms for Supplier Development in Mega Construction Projects	IEEE Transactions on Engineering Management	Zeng, W.; Wang, H.; Li, H.; Zhou, H.; Wu, P.; Le, Y.	2019
Managing interactive collaborative mega project supply chains under infectious risks	International Journal of Production Economics	Zhao, N.	2019
What Are the Causes and Cures of Poor Megaproject Performance? A Systematic Literature Review and Research Agenda	Project Management Journal	Denicol, J.; Davies, A.; Krystallis, I.	2020
An Ontology and Multi-Agent Based Decision Support Framework for Prefabricated Component Supply Chain	Information Systems Frontiers	Du, J.; Jing, H.; Choo, K.-K. R.; Sugumaran, V.; Castro-Lacouture, D.	2020
Assessing project risks from a supply chain quality management (SCQM) perspective	International Journal of Quality and Reliability Management	Gaudenzi, B.; Qazi, A.	2020
Exploring the emergence of lock- in large-scale projects: A process view	International Journal of Project Management	Hetemi, E.; Jerbrant, A.; Mere, J. O.	2020
Effects of employing third-party logistics arrangements in construction projects	Production Planning and Control	Janné, M.; Rudberg, M.	2020
Airport project delivery within BIM-centric construction technology ecosystems	Engineering, Construction and Architectural Management	Keskin, B.; Salman, B.; Ozorhon, B.	2020
Dimensions of governance in interorganizational project networks	International Journal of Managing Projects in Business	Kujala, J.; Aaltonen, K.; Gotcheva, N.; Lahdenperä, P.	2020
Integrated construction supply chain: an optimal decision-making model with third-party logistics partnership	Construction Management and Economics	Le, P. L.; Jarroudi, I.; Dao, T.-M.; Chaabane, A.	2020
Profit Sharing Mechanism of Large EPC Project considering the Behavior of Fairness Concern	Advances in Civil Engineering	Li, H.; Lv, L.; An, X.; Dong, G.	2020
Introducing a multi-criteria evaluation method using Pythagorean fuzzy sets A case study focusing on resilient construction project selection	Kybernetes	Mohagheghi, V.; Mousavi, S. M.; Mojtahedi, M.; Newton, S.	2020
Responsibilities and accountabilities for industrial facility commissioning and startup activities	Construction Innovation	O'Connor, J. T.; Mock, B.	2020
A systematic review of China's belt and road initiative: implications for global supply chain management	International Journal of Production Research	Thürer, M.; Tomašević, I.; Stevenson, M.; Blome, C.; Melnyk, S.; Chan, H. K.; Huang, G. Q.	2020
Improving Information Sharing in Major Construction Projects through OC and POC: RDT Perspective	Journal of Construction Engineering and Management	Zhang, L.; Yuan, J.; Xia, N.; Bouferguene, A.; Al-Hussein, M.	2020

Appendix E. – Coding structure example

Paper	Paper level coding		Evidence	Node level coding				Metrics	
	Category	Subcategory		Node Name	Interface	Subcategory	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-organizational	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, modularity, platforms, just- time- time logistics, and new techniques such as Design for Manufacture and Assembly (DfMA) and artificial intelligence are being applied to enhance the performance of megaproject production systems."	Bridging the gap with manufacturing	Production and Logistics Strategies	Production Strategies	Intra-organizational		
			"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 and Collaboration	Social aspects, communication and Mechanisms	Inter-organizational		
			"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-organizational		
			"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,	Decomposing and integrating the supply chain	Inter-firm Coordination and Collaboration	Coordination, Collaboration and Mechanisms	Inter-organizational		

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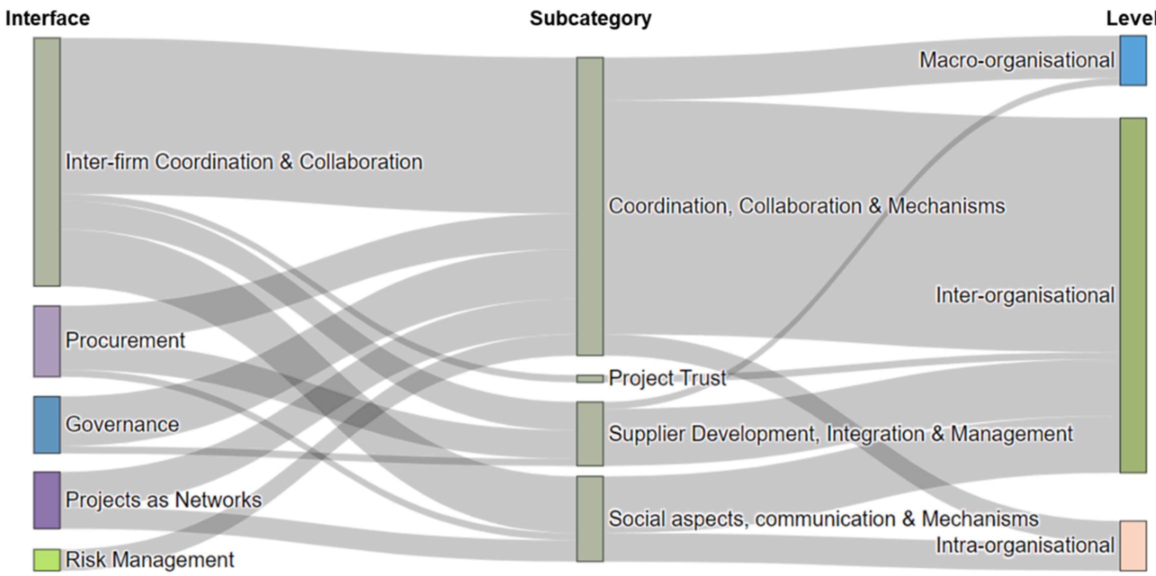
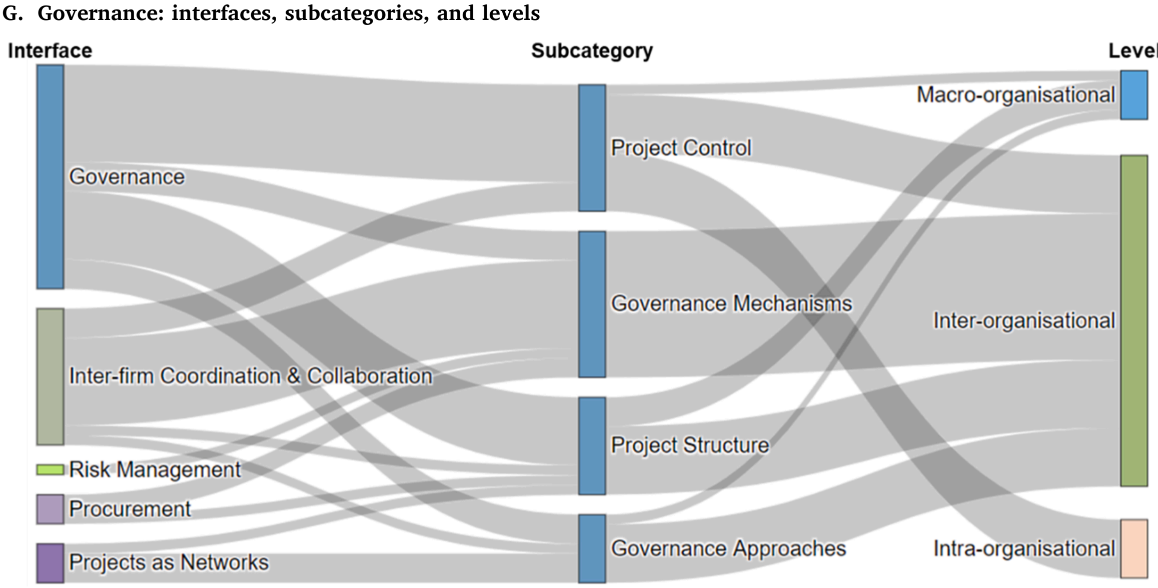
Paper	Paper level coding		Evidence	Node level coding				Metrics	
	Category	Subcategory		Node Name	Interface	Subcategory	Level	Paper	Nodes
			different behaviors, and priorities of numerous suppliers involved in a megaproject (Pryke, 2020). Studies might examine how suppliers are incentivized to achieve 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)."						
(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-organizational	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-organizational		
			"(…) 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 and Collaboration	Coordination, Collaboration and Mechanisms	Inter-organizational		
			"(…) 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-organizational		
Total								**2**	**9**

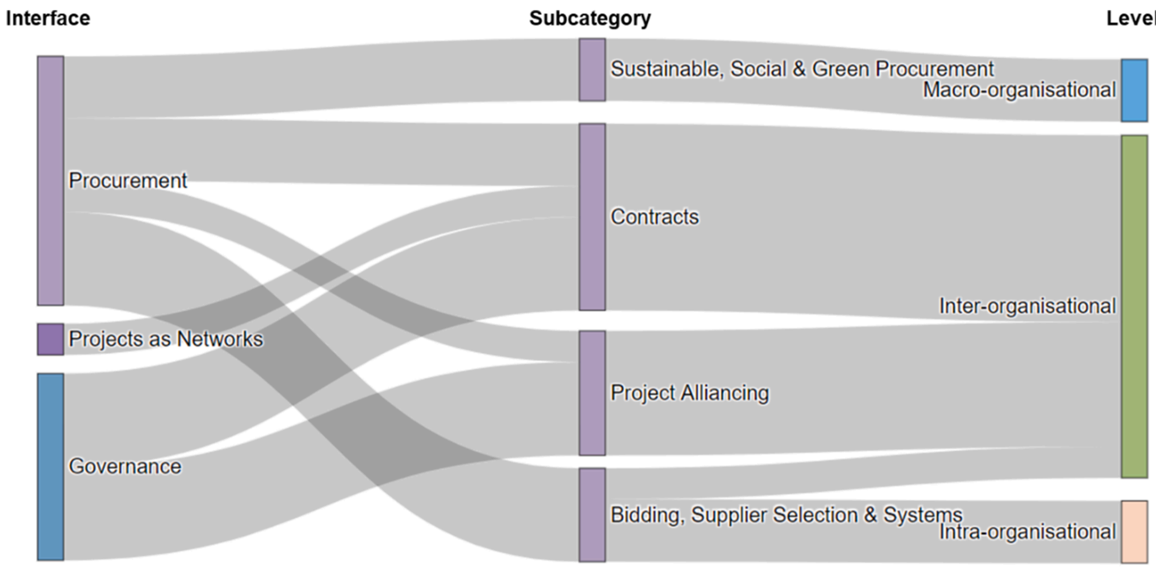
Appendix F. Inter-firm coordination and collaboration: interfaces, subcategories, and levels



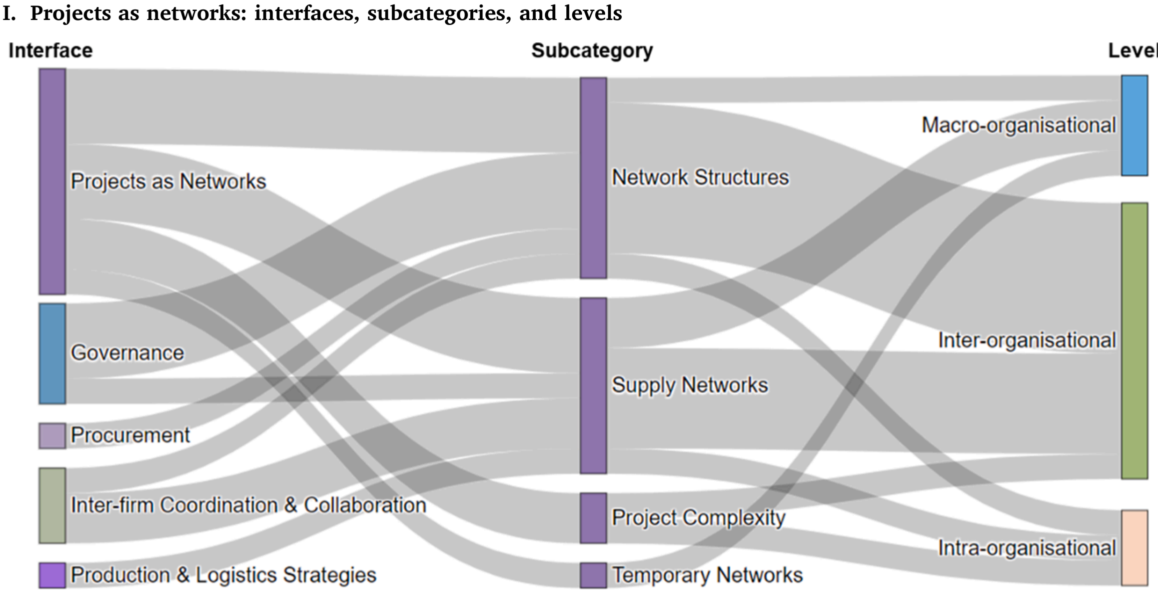
Appendix G. Governance: interfaces, subcategories, and levels



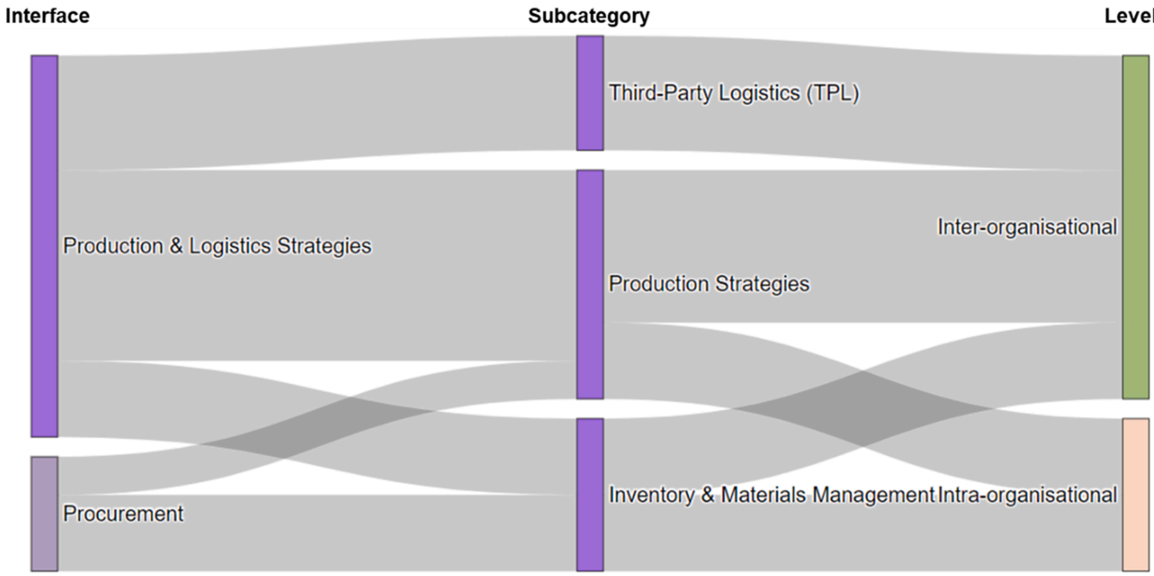
Appendix H. Procurement: interfaces, subcategories, and levels



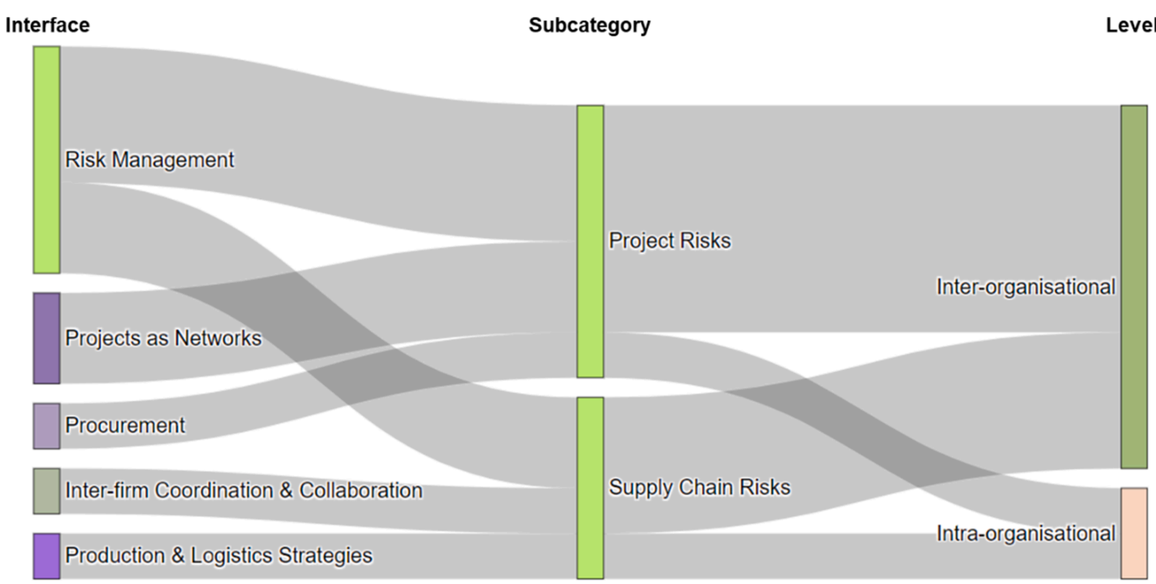
Appendix I. Projects as networks: interfaces, subcategories, and levels



Appendix J. Production and logistics strategies: interfaces, subcategories, and levels



Appendix K. Risk management: interfaces, subcategories, and levels



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