Inter-Organizational Collaboration in Interconnected Infrastructure Projects

de Bruijne, Mark L.C.; Hertogh, Marcel J.C.M.; Bakker, Hans L.M.; Nezami, Maryam R.

DOI
10.3390/su15086721

Publication date
2023

Document Version
Final published version

Published in
Sustainability

sustainability

MDPI

Article

Inter-Organizational Collaboration in Interconnected Infrastructure Projects

Maryam R. Nezami [1,*], Mark L. C. de Bruijne [2], Marcel J. C. M. Hertogh [1] and Hans L. M. Bakker [1]

[1] Faculty of Civil Engineering and Geosciences, Delft University of Technology, Stevinweg 1, 2628 CN Delft, The Netherlands; m.j.c.m.hertogh@tudelft.nl (M.J.C.M.H.); h.l.m.bakker@tudelft.nl (H.L.M.B.)
[2] Faculty of Technology, Policy and Management, Delft University of Technology, Jaffalaan 5, 2628 BX Delft, The Netherlands; m.l.c.debruijne@tudelft.nl
* Correspondence: m.rikhtegarnezami@tudelft.nl

Abstract: This study aims to identify which factors affect inter-organizational collaboration (IOC) in interconnected infrastructure projects to enable practitioners to establish a collaborative environment at the project level. This specific form of inter-organizational collaboration (IOC) is characterized as "horizontal" and has received limited attention in the literature. To this end, a systematic literature review and Q-methodology were conducted. The Q-methodology involves practitioners from various infrastructure organizations in the Netherlands gaining insights into their perspectives on IOC in interconnected infrastructure projects. The study identifies two perspectives: a "holistic, goal-oriented" perspective that recognizes various dimensions of IOC and a more "people-oriented" perspective that emphasizes the value of individual factors for IOC. The findings suggest that multiple perspectives on collaboration exist among practitioners, potentially affecting collaboration in interconnected infrastructure projects. Awareness of the need to manage practitioners' perspectives, and addressing and discussing these differences, can stimulate inter-organizational collaboration and contribute to improved project performance.

Keywords: inter-organizational collaboration; collaboration factors; interconnected infrastructure projects

Citation: Nezami, M.R.; de Bruijne, M.L.C.; Hertogh, M.J.C.M.; Bakker, H.L.M. Inter-Organizational Collaboration in Interconnected Infrastructure Projects. *Sustainability* **2023**, *15*, 6721. https://doi.org/10.3390/su15086721

Academic Editor: Ripon Kumar Chakrabortty

Received: 17 March 2023
Revised: 13 April 2023
Accepted: 14 April 2023
Published: 16 April 2023

1. Introduction

Critical infrastructures, such as energy, water, transportation, and IT-based services, play a crucial role in providing essential services to communities and businesses. This, in turn, drives economic growth and contributes to the advancement of society. However, many infrastructures are approaching the end of their technical or functional lifetime in many countries [1]. Hence, many infrastructures and their assets need to be replaced, upgraded, or developed to meet the requirements of sustainable growth and address upcoming environmental challenges.

The next generation of infrastructures is expected to cope with the entangled state of today's infrastructures, which often intersect, interconnect, or exist in close proximity to each other, particularly in urban areas. In these environments, a higher level of interdependence between infrastructure projects is anticipated, necessitating closer collaboration between infrastructure owners in such projects. For next-generation infrastructure projects, collaboration among infrastructure owners is not simply a preferred approach, but a fundamental requirement to address the challenges and uncertainties arising from these interconnections [2,3], which requires new techniques, working methods, and processes.

The interconnected nature of infrastructures demands increased inter-organizational collaboration to address uncertainties [2,4]. The existing literature on IOC recognizes that knowledge and resource sharing through collaboration stimulates multidisciplinary knowledge development and competencies among practitioners that cannot be obtained from individual organizations [4]. Knowledge and resource sharing during collaborations

also enables the development of innovative solutions for complex problems, which improves equity and lowers risk among collaborators, achieves more fruitful outcomes, and reduces reworking [5–8]. Collaboration increases the possibility of synergy by bringing multidisciplinary parties together to share their knowledge and generate better outcomes in comparison with those produced in isolation [9] and produces flexibility through the combining and sharing of competencies [10].

However, despite the widely recognized benefits of IOC, there is also evidence that the full potential of collaboration is rarely reached [11–14]. IOC is a formidable challenge, primarily due to the presence of conflicting interests between the participating organizations [15,16]. In addition, organizations participating in IOC face problems that require significant efforts from various parties to resolve and are of a different kind and higher complexity than what they may encounter in their own organizations [17]. Rigid organizational boundaries, poor communication, and a lack of mutual understanding frustrate IOC [18]. To help improve collaboration and unleash its full potential, it is important to identify which factors affect IOC. The practical factors that contribute to collaboration seeking to stimulate joint working, joint decision-making, and the solving of collective problems are often underrated and overlooked [19–21].

Construction literature primarily identifies factors that support collaboration within the construction supply chain [22,23] and from the contractors' perspective [24,25]. However, empirical research that identifies what factors contribute to collaboration between infrastructure owners (i.e., horizontal collaboration) in interconnected infrastructure projects has not yet been thoroughly addressed.

This research represents a novel endeavor in the identification and examination of critical factors that contribute to horizontal collaboration in interconnected infrastructure projects. Accordingly, this research contributes to both the conceptual and practical study of IOC. The methodology of this research consists of two parts: a systematic literature review and a Q-methodology. The literature review was performed to identify the underlying factors of horizontal collaboration in interconnected infrastructure projects, while the Q-methodology was used to elicit the perspectives of infrastructure practitioners on collaboration in such projects. The remainder of the paper is structured as follows: Section 2 outlines the research methodology, Section 3 presents the literature review, Section 4 explains the Q-methodology, Section 5 describes the results of the Q-methodology, Section 6 discusses the findings, and Section 7 concludes the study.

2. Research Methodology

In search of a comprehensive overview of factors that contribute to IOC, three different sources of knowledge were used: academic literature, preliminary research on IOC in interconnected infrastructure projects, and findings from a single case study of an interconnected infrastructure project in the Netherlands.

2.1. Literature Study

The Scopus and Web of Science databases were searched to identify scientific literature that reports on the factors of inter-organizational collaboration from the last 20 years. The search terms used to identify potentially relevant publications included "Inter-organizational collaboration" OR "Horizontal collaboration" AND "Factor" OR "Indicator" OR "Element". The search results were limited to (fields of study: management, engineering, and social sciences; Language: English; and type of document: journal articles). After this database search, the results were filtered based on an analysis of the title and abstract. A second filtering was performed via a comprehensive review of the remaining articles. The literature review and analysis resulted in a shortlist of 10 papers, which, altogether, identified 40 factors of IOC (see Table A2 in Appendix A).

2.2. Preliminary Research

A secondary source of factors of IOC was found through preliminary research conducted by the authors on the state of IOC in Dutch interconnected infrastructure projects [12]. Practitioners with experience in interconnected infrastructure projects and IOC were interviewed to determine the factors that practitioners think contribute to collaboration. In total, 25 factors were mentioned (see Table A3 in Appendix A).

2.3. Single Case Study

Interviews were conducted as part of a case study aimed at improving collaboration between two infrastructure owners in an interconnected infrastructure project in the Netherlands. Semi-structured interviews were held with practitioners in 16 key roles in cross-infrastructural project teams, who mentioned 29 factors of IOC (see Table A4 in Appendix A).

2.4. Q-Methodology

The lists of factors identified via the various sources were used as inputs for the Q-methodology study to investigate infrastructure practitioners' perspectives regarding the factors of IOC. Q-methodology is a generic research method that combines quantitative and qualitative techniques to explore the perspectives of respondents on specific issues or topics [26,27]. The implementation of Q-methodology is discussed in detail in Section 4.

3. Literature Review

An extensive list of factors was identified through an analysis of the literature data related to the factors of inter-organizational collaboration (IOC). However, to maintain conciseness, this study specifically discusses the critical factors of IOC that have been introduced in each study, while the complete list of factors can be found in Appendix A. The present section outlines the factors that were identified through an analysis of the relevant literature. These factors will be combined with those identified in practice. The resulting list of factors will serve as the input for a Q-methodology study, the findings of which will be discussed from the standpoint of infrastructure practitioners' perspectives. A comprehensive list of identified factors is provided in Appendix A, Table A1. Some of the previous studies have categorized these factors, and this study discusses these categories in detail.

3.1. Key Factors

Verdecho et al. [28] consider top management support, leadership, shared vision, trust, and commitment to be critical factors of IOC. Jacobson and Choi [29] identify open communication, commitment, and willingness to collaborate as key factors enhancing collaboration. These factors were among the ten factors that were identified as sources of collaboration, including the creation of a shared vision, commitment, communication, trust, willingness to collaborate, respect, political support, technical knowledge, shared pain and gain, and clear roles and responsibilities. In addition to shared vision, commitment, trust, and clear roles, Dietrich et al. [30] claim that physical and cultural proximity, conflict resolution, and expectation fulfillment enhance IOC in multi-partner projects.

Smith and Thomasson [31] and Savolainen et al. [32] recognize communication as a key factor contributing to collaboration. In addition to communication, factors such as shared vision, organizational culture, unity, commitment, and the early involvement of participants are identified to facilitate IOC [19,31]. To establish a collaborative environment, Sujan et al. [33] identify critical factors that are essential to enhancing collaboration. These factors include motivation, working relationships, leadership, communication, early involvement of participants, and an emphasis on the relational aspects of inter-organizational collaboration.

The abovementioned factors of IOC identified through the literature study were utilized as a knowledge source to conduct the Q-methodology. These factors are reported in Table A2 of Appendix A.

3.2. Categories of Factors Reported in the Literature

Getha-Taylor [34] argues that collaboration with other organizations creates public value and requires the development of specific individual collaborative skills such as interpersonal understanding, adaptability, and individual competency. Similarly, O'Leary et al. [35] argue that individual aspects determine whether IOC will be facilitated or hampered. O'Leary et al. [35] present five categories: individual attributes, interpersonal skills, group process skills, strategic leadership, and the technical knowledge of collaborators. This, however, differs from the categories identified by Verdecho et al. [28], which go beyond the individual domain and include strategy, culture, process, and organizational structure. Faris et al. [19] identify six categories of factors of IOC in construction projects: project vision, collaborators' behavior, communication, relationship definitions, agreements, and systematic process. Kożuch and Sienkiewicz-Małyjurek [20] identify five categories of IOC factors, including external environments, organizational characteristics, individual characteristics, relational factors, and instruments. Finally, Kożuch and Sienkiewicz-Małyjurek [20] claim that organizational characteristics and relational factors have the greatest influence on IOC.

The literature presents various categories of factors influencing IOC, some of which partially overlap. Despite the diverse terminology used to categorize these factors, they can be categorized into three broad themes or sets of characteristics: individual characteristics, the relationship between collaborators, and the structural and organizational aspects of IOC.

4. Q-Methodology

The Q-methodology was conducted to study practitioners' perspectives on (factors of) IOC in interconnected infrastructure projects in the Netherlands via four subsequent steps [36]: (1) the collection of the concourse and the Q-set; (2) the selection of respondents (P-set); (3) the sorting of statements (Q-sort); and (4) data analysis.

4.1. Concourse Collection

The concourse is the collection of all relevant data about the subject of a study [37]. The concourse in this research consists of a list of 47 factors of IOC from the 3 different sources of knowledge (see Section 2), which are listed in Table A1 of Appendix A.

A Q-set was extracted from the concourse. The Q-set contains 36 statements about the factors of IOC in interconnected infrastructure projects that were mentioned in at least 2 different sources of knowledge to reduce the size of the Q-set (see Table A1 of Appendix A). The list of Q-statements provided to respondents during the sorting process includes three categories to simplify the interpretation of various factors in practical settings: individual collaborative capacity (ICC), relational collaborative capacity (RCC), and organizational collaborative capacity (OCC), as presented in Table 1. The inclusion of these categories was a deliberate effort to aid respondents. It is important to note that these categories cover the critical factors of inter-organizational collaboration (IOC) and are consistent with categories proposed in prior research, such as the categories proposed by Foster-Fishman et al. [38].

4.2. P-Set

The second step of the Q-methodology concerns the selection of respondents (P-set) [36]. To gain various perspectives, 15 respondents from different infrastructure organizations with varying functions and degrees of experience (from 10 to 40 years) in IOC in the Netherlands were selected to conduct the Q-sorting. Table 2 presents a summary of the respondents' functions in the present work.

Table 1. Q-set.

Category	Q-Statement
Individual collaborative capacity (ICC)	1. Commitment 2. Respect among people 3. Willingness to collaborate 4. Interpersonal understanding 5. Understanding the mutual expectations 6. Individual competency for collaborative tasks 7. Professional and technical expertise of collaborators 8. Previous inter-organizational collaboration experience 9. Getting to know each other 10. Having fun 11. Relationship building
Relational collaborative capacity (ICC)	12. Unity with no organizational boundaries 13. Early involvement of key participants 14. Reciprocated Trust 15. Openness 16. Adaptability 17. Common goal and shared vision 18. Inclusive coordination and teamwork 19. Joint decision-making 20. Management via a common collaborative process 21. Equality between collaborating parties 22. Balanced relationship 23. Shared organizational culture 24. Understanding of different organizational culture
Organizational collaborative capacity (ICC)	25. Collaborative leadership 26. Top management support 27. Frequent, high-quality, professional communication 28. Direct informal communication 29. Safe environment 30. Resource sharing 31. Clear definition of roles and responsibilities 32. Collaborative legal agreement 33. Collaborative common ground rules 34. Collaborative tools and technologies 35. Regulations and government support 36. Share pain and gain

Table 2. An overview of the respondents' functions in this study.

Function	Number of Respondents
Project director	3
Project manager	3
project control manager	3
Technical manager	2
Developer	2
Senior manager	1
Stakeholder manager	1

4.3. Q-Sorting

The next step in Q-methodology is the actual Q-sorting. Statements that contain factors from the Q-set (Table 1) are placed on individual cards, and the respondents are invited to sort them on a scale from "Totally disagree" (−3) to "Totally agree" (+3) on a seven-column grid (the scoreboard) representing a quasi-normal distribution (see Figure 1). (The respondents were asked "Which are the most or least important factors for inter-organizational

collaboration in interconnected infrastructure construction projects?" and subsequently invited to sort the Q-statements on the scoreboard according to their preference.)

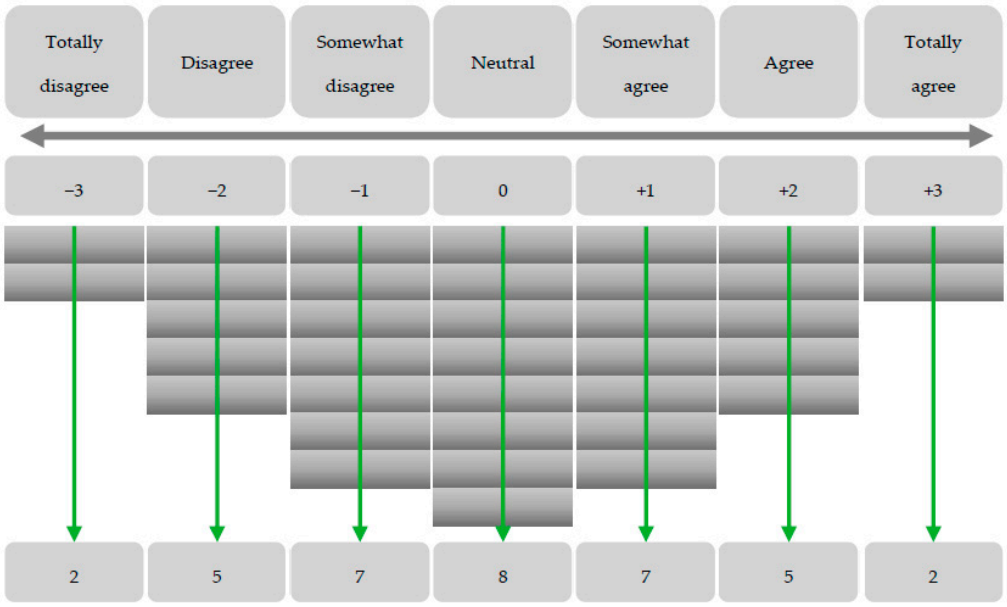

Figure 1. Scoreboard for Q-sorting.

As the research was conducted under COVID-19 restrictions, which hampered face-to-face contact, the Q-set was shared electronically with the respondents for sorting using an online platform (www.qsortware.net (accessed on 20 October 2020)). During the meeting, respondents were guided through the Q-sorting process via stepwise sorting instructions. Sorting took place in two steps. First, respondents were asked to allocate statements to one of the three columns, Disagree, Neutral, or Agree, without posing any restrictions [39]. The second sorting step consisted of inviting the respondents to place the statements from the three columns on the scoreboard [39] (see Figure 1). During and after the sorting process, the respondents are asked to explain their sorts, and follow-up questions are asked to clarify the respondents' actions (e.g., why they placed certain statements somewhere in the three columns or on the Q-sorting scoreboard).

4.4. Data Analysis

In the final step of the Q-methodology, the completed sorts of the respondents are analyzed. First, a factor analysis is conducted to identify correlations between the sorting of the individual statements of the respondents. Next, the results of the factor analysis are analyzed to extract a number of perspectives, which, in essence, assesses the key sorting patterns of the respondents (i.e., the level of similarity of every Q-sort generated by the P-set).

The PQ-Method 2.35 program was used to conduct the data analysis. There is no correct number of factors, and the researcher can decide how to analyze the sorting based on the following criteria. How many meaningful factors to include in the analysis is decided based on two parameters [37]: (1) the cumulative percentage of explained variance is more than 50%, and (2) the highest two-factor loadings should at least be equal to 2.58 times the standard error (SE), which is equal to $2.58\frac{1}{\sqrt{N}}$, with N being the number of statements equal to 36. Based on the mentioned parameters, two, three, or four perspectives can be extracted.

Next, the criteria introduced by Webler et al. [40] are used, which are simplicity, clarity, distinctness, and stability. In comparison with other factor solutions, a two-factor solution is simpler. With a smaller number of perspectives, it is clearer; no non-loaders occur; and it is more stable, as the perspectives extracted have a higher number of loaders. In this research, a two-factor extraction solution was thus decided upon. Based on analysis of the results

of the Q-sorting and the interviews with the respondents, two distinct perspectives were labeled as follows: Perspective 1: holistic goal-oriented and Perspective 2: people-oriented. Two perspectives with nine and six loaders are shown with Z-score and Q-score values in Table A5 of Appendix A. These two perspectives are discussed in Section 5.

5. Results

5.1. Perspective 1 (Holistic Goal-Oriented)

The first perspective was labeled as holistic goal-oriented. Nine respondents loaded on the first perspective, accounting for 28% of the explained variance. The factor scores of the top seven and bottom seven statements for this perspective are depicted in Figure 2. The factor is distinguished at $p < 0.01$.

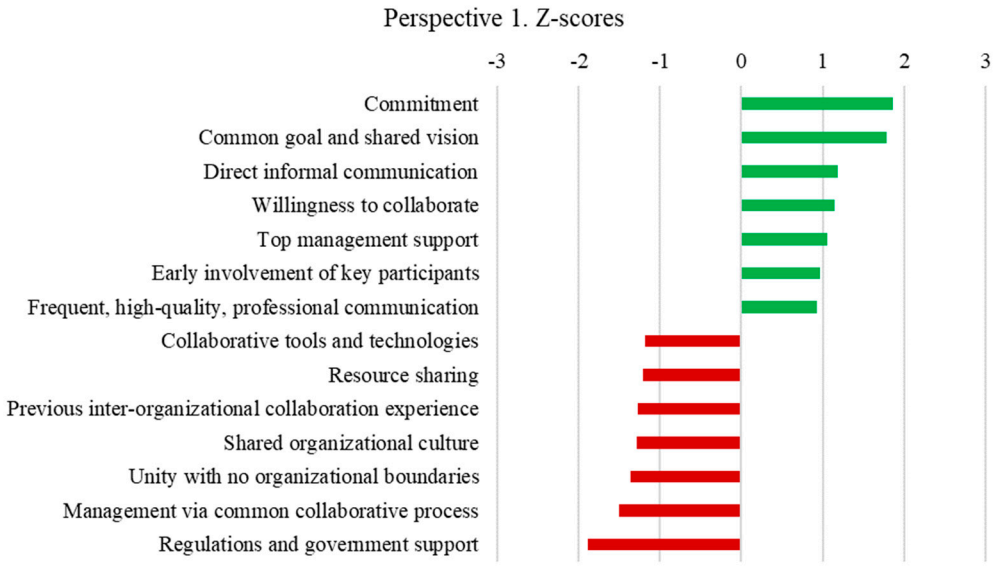

Figure 2. Perspective 1.

According to this group of respondents, the most important factors of IOC are *commitment* (+3) and *common goals and shared vision* (+3). They believe that the commitment of organizations leads to achieving the best outcome in IOC: *"In the word commitment I see a lot of things, I see that you want to build a relation, want to be understanding, want to communicate, you are doing everything in your power to succeed"*. The respondents also state that, without a common goal and shared vision among the collaborators, there will be no collaboration. However, it does not mean that organizations cannot pursue their own goals. They can align their own goals to benefit from IOC: "*You can have your own goals, but the common goal is always the main goal holding the collaborating parties together*". A respondent adds that "*If organizations need similar things and have a shared vision they will collaborate and find a common solution for a common project*".

Another factor that is reflected in this perspective is (formal and informal) communication (+2). The respondents emphasize the importance of informal communication and consider that it also influences other factors of IOC, such as trust and interpersonal understanding: "*Informal communication is essential to build the relationship, it can help to create a better understanding between organizations and build trust among them*". Furthermore, the respondents believe that formal and informal communication facilitates data sharing between infrastructure organizations and leads to efficient decisions in IOC. It is also worth noting that there exists a potential relationship between the identified factors of IOC. According to the respondents, enhancing communication has the potential to improve mutual trust and understanding within a collaborative team.

The group of respondents making up this perspective further believes that regulations and government support and management via a common collaborative process (−3) are not

critical for IOC, and it can function without these factors. The respondents emphasize this by pointing out that "*every infrastructure organization has its own management and processes and can work on its own parts of the project with its own processes, while IOC can still work*".

5.2. Perspective 2 (People-Oriented)

Six respondents loaded on the second perspective, which is labeled people-oriented, accounting for 23% of the explained variance. The characterizing statements (top seven and bottom seven) of the second perspective are shown in Figure 3.

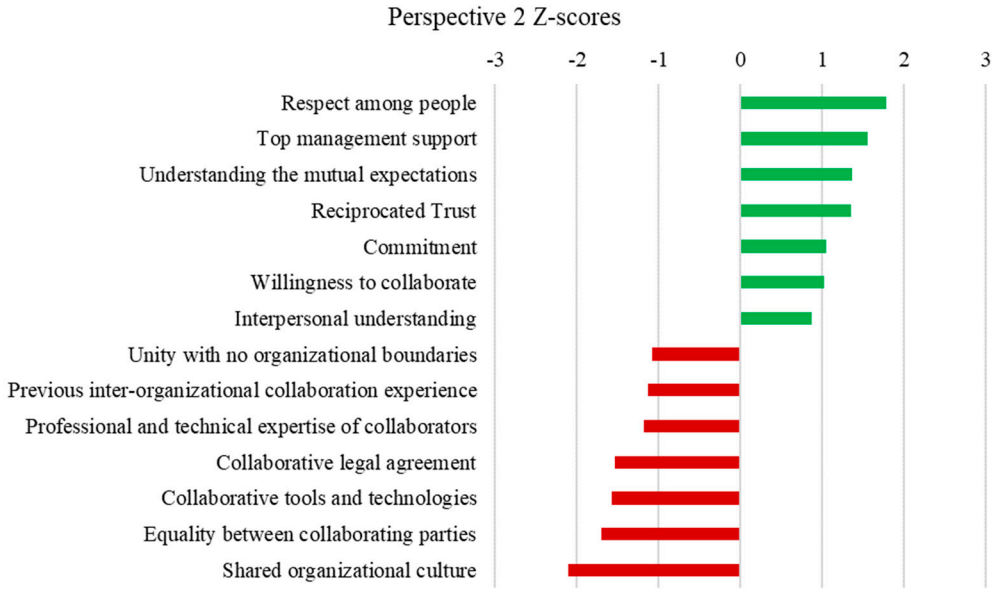

Figure 3. Perspective 2.

The highest-ranking factors in the second perspective are respect among people (+3) and top management support (+3). The respondents stress that respect among people is of key importance throughout the whole project and can prevent potential conflicts. The respondents also consider top management support essential for IOC and the achievement of results: "*The desired results will not be reached without the support of the top management*".

Understanding mutual expectations (+2) is also considered an important factor of IOC. "*Especially in the beginning you should be clear on what you expect from each other*", states one respondent since each organization has its own interests and expectations, which are the triggers for joining a collaborative project. According to the group making up Perspective 2, reciprocated trust (+2) is important because it enhances the relationship between the organizations and facilitates collaboration: "*You should work to earn the trust of other parties so that you go on further in the project*". The respondents believe that a lack of trust affects the whole relationship and creates conflict in IOC.

Equality between collaborating parties (−3) and shared organizational culture (−3) are not considered necessary as building blocks of IOC according to this perspective. A respondent expresses that "*it is a fact that inequality exists. Sometimes hierarchy between organizations is needed for proper functioning in IOC*". This group also declares that lack of shared organizational culture is generally not an issue in IOC: "*Organizational culture is never an issue when you understand each other*". One respondent adds that "*we are professionals and need to accept that each organization has its own culture*".

5.3. Comparison of Perspectives

The similarities and differences between Perspectives 1 and 2 are not all that large. Among the seven highest-ranked statements, three of them are similar in both perspectives (commitment, willingness to collaborate, and top management support). Four of the seven

lowest-ranked statements are also present in both perspectives (collaborative tools and technologies, previous inter-organizational collaboration experience, shared organizational culture, and unity with no organizational boundaries*).*

The most distinguishing statements between the first and second perspectives are direct informal communication (+1.89) and regulations and government support (−2.53). According to the group of respondents in Perspective 1, informal communication is critical for IOC but not so much for those loading on the second perspective, while regulations and government support are advocated by respondents loading on the second perspective and not by those loading on Perspective 1.

Respondents loading on Perspective 1 ranked informal communication as the third highest statement. They see informal communication as a facilitator or indirect contributor to other factors of IOC. However, respondents belonging to the group who load on Perspective 2 ranked direct informal communication as the 27th statement, which is on the negative side of the Q-sorting bell shape.

In this study, two distinct perspectives were identified regarding the factors influencing the implementation of inter-organizational collaboration (IOC). The first perspective is characterized by a holistic approach that encompasses factors embedded in all three categories of IOC: individual (ICC), relational (RCC), and organizational (OCC) collaborative capacities. This perspective suggests that a comprehensive view of IOC is necessary to effectively implement it. Additionally, the respondents in the study exhibited a heightened commitment to IOC when a clear common goal was established. As a result, this perspective is labeled "holistic goal-oriented".

The second perspective, however, primarily emphasizes the individual dimension of IOC, although it does not prioritize informal communication. This approach is labeled "people-oriented" and centers around fostering respect and mutual understanding between individuals to establish effective interpersonal relationships. The focus is on developing an understanding of mutual expectations and interpersonal dynamics. This perspective is best described as centered around developing an interpersonal understanding to establish a collaborative environment. The second perspective emphasizes the importance of individual-level factors in achieving a successful IOC. This perspective recognizes that people play a crucial role in shaping the outcomes of IOC and that their attitudes, behaviors, and skills can either facilitate or hinder the collaborative process. Therefore, this perspective emphasizes the need to develop an interpersonal understanding among the participants, which can be achieved through formal communication channels, such as meetings, reports, and agreements.

6. Discussion

Performing the Q-methodology in this research enabled the development of two perspectives: the holistic goal-oriented perspective with nine respondents loading on it and the people-oriented perspective with six loaders. The holistic goal-oriented perspective assumes that IOC requires the presence of factors from all three categories. The most important factors of IOC in the holistic goal-oriented perspective are commitment and common goal and shared vision. These factors are also mentioned with high frequency in the literature. Setting a common goal and shared vision is considered a key factor in establishing a collaborative environment [19], and commitment is mentioned as an essential factor of IOC [31]. Commitment, which is essential for collaboration, drives involvement from all participants, ultimately leading to the accomplishment of the agreed-upon goals [29].

The holistic goal-oriented perspective, unlike the second perspective, emphasizes the importance of formal and informal communication. Communication enhances collaborative relationships and information sharing, which, in turn, are required to achieve common goals. According to Perspective 1, the majority of information that needs to be exchanged occurs through informal communication, which facilitates IOC. Communication and interaction between collaborators are considered simple and effective tools to trans-

fer information, maintain relationships [33], and improve workflows in IOC [32]. Sujan et al. [33] emphasize that informal communication enhances collaborative projects. A form of informal communication, such as personal dialog, benefits practitioners by allowing them to develop a mutual understanding and enabling them to quickly solve practical issues [41]. It indicates the presence of a potential relationship between communication and interpersonal understanding in IOC.

Perspective 1 prioritizes the mutual management of a collaborative project and values factors such as a common goal and shared vision, informal communication, and willingness to collaborate as important factors of IOC. However, this perspective does not advocate for resource sharing, having common processes, or unity among the parties in IOC. It seems that there is a tendency to focus on one's own organization and its procedures rather than the common and collaborative ones. Verdecho et al. [28] argue that, although each organization in the collaboration maintains its own structure and procedures, an inter-organizational structure and common procedures need to be developed to facilitate collaboration in complex projects.

The people-oriented perspective focuses on the individual aspects of IOC, such as respect among people, understanding mutual expectations, commitment, willingness to collaborate, and interpersonal understanding. The individual skills of employees who engage in collaboration, relationships with individuals in the IOC, understanding mutual interests, and sharing the individual expectations of the collaboration are considered fundamental to accomplishing a collaborative project [35,42]. Respecting each other and understanding each other's opinions helps to build a collaborative environment in which support, mutual goal setting, and shared achievements can feature [35]. It is remarkable that informal communication is not appreciated by the respondents loading on Perspective 2 even though they consider mutual and interpersonal understanding important factors of IOC. To enhance mutual understanding among organizations, informal communication is considered beneficial [41].

The group making up the second perspective advocates top-management support and government support, which indicates that this perspective recognizes the importance of external support to organizing and improving IOC. This perspective favors a hierarchical structure and governmental policies to facilitate IOC. Jacobson and Choi [29] also argue that political regulations can serve to improve IOC when conflicts or disagreements arise between the parties. However, Phillips et al. [43] believe that IOC is a collaborative relationship without "*hierarchical mechanisms of control*". There is a need to find a balance between self-governance, where the parties collaborate to formulate their own collective solutions, and hierarchical governance [44].

Both perspectives can coexist in a collaborative project. Advocates of Perspective 1 prefer to jointly manage the project and communicate informally to achieve common goals, while advocates of Perspective 2 value individual characteristics in the collaboration and prefer hierarchical and governmental support to achieve success in IOC.

The differences in these perspectives could help explain why collaboration in construction projects is so hard to achieve. Misunderstanding can exist between individuals in collaborative projects because individuals seem to have diverging ideas about what is required for collaboration, and this may even result in conflicts in the collaboration. However, being aware of the differences and openly sharing viewpoints on collaboration at the early stages of it (when the project team is formed) can enhance mutual understanding in collaboration [45] and can be considered an opportunity for collaborators to inform and complement each other. Learning which perspectives are present among the members of a collaborative project can contribute to synergy in IOC. During the formation of the project team, the team can discuss preferred ways of working, share attitudes toward collaboration, and discuss differences in their perspectives to develop an agreement on how to collaborate and facilitate the process of collaboration [45].

Another point of discussion is the commonality of low-ranked statements, such as shared organizational culture, management via a common collaborative process, unity with

no organizational boundaries, and collaborative tools and technologies. These factors are signs of creating one project organization with common processes and procedures. The research findings suggest that practitioners prefer to perform a common project primarily on their own and based on their own processes. Disunity between the collaborators, the use of different processes and procedures, and cultural differences could be identified as potential challenges that can hinder effective IOC [16]. O'Leary et al. [35] also argue that collaboration encounters difficulties due to differences in goals, cultures, procedures, and processes. A shared organizational culture improves collaborative learning, satisfaction, and communication between the parties in IOC [46]. Shared organizational culture can be developed by working across organizational boundaries and being a united team [31]. Unity and a collaborative spirit between the parties increase the quality of IOC [30,47]. Therefore, creating an integrated project team with common processes and procedures and a shared culture can overcome potential challenges and facilitate IOC.

7. Conclusions

Realizing interconnected and interdependent infrastructure projects in a dynamic environment requires that infrastructure operators combine multidisciplinary knowledge and rely on collaborative skills to achieve IOC. This study identifies factors of IOC that can enable practitioners to establish a collaborative environment to work on the realization of interconnected infrastructure projects. The factors of IOC are identified through the literature study and performing a Q-methodology. This study utilized a Q-methodology study to analyze the factors of inter-organizational collaboration (IOC) in the context of interconnected infrastructure projects.

The results of the study suggest that shared organizational culture, management via a common collaborative process, and unity without organizational boundaries are viewed by practitioners as relatively low-significance factors in inter-organizational collaboration for interconnected infrastructure projects. However, previous studies have highlighted that differences in cultures, processes, and procedures between infrastructure owners can be potential obstacles to successful collaboration. This prevalence of fragmented practices among infrastructure owners suggests a siloed mentality that prioritizes individual procedures over integrated and collaborative approaches. Further research is needed to gain a deeper understanding of the role and impact of these factors on inter-organizational collaboration in interconnected infrastructure projects.

The Q-methodology revealed two distinct perspectives: the holistic goal-oriented perspective and the people-oriented perspective. The holistic goal-oriented perspective emphasized the importance of formal and informal communication between collaborators and incorporated factors from all three categories of collaborative capacity (individual, relational, and organizational). The people-oriented perspective prioritized the individual dimension of IOC and highlighted the significance of top-management and government support in facilitating the realization of joint infrastructure projects. These perspectives provide valuable insights into the multifaceted nature of inter-organizational collaboration in the context of infrastructure projects.

No one perspective is inherently superior to the other, and both can exist within project teams. Therefore, the managerial implication of this study is that practitioners involved in interconnected infrastructure projects should acknowledge the existence of diverse perspectives on collaboration and their potential impact on it. To achieve synergistic collaboration within a project, it is important to effectively manage different perspectives and consider them complementary. This requires a deep understanding of the differences between the practitioners' perspectives on collaboration and the ability to create a collaborative environment that considers various factors contributing to successful inter-organizational collaboration. The main building blocks of inter-organizational collaboration (IOC) were identified through the high-ranked statements across the perspectives. These building blocks include commitment, respect among people, common goal and shared vision, and

top management support. These factors can be leveraged to promote effective collaboration and achieve common goals in an infrastructure project.

In this study, the background information of the practitioners was noted, such as years of working experience and roles in infrastructure organizations. The findings indicate that the identified perspectives are independent of years of experience and the roles the respondents perform. We recommend conducting further investigations into this relationship.

Based on the preliminary findings of the present study, it has become evident that the identified factors of inter-organizational collaboration (IOC) have the potential to influence one another. While this suggests the existence of a complex and dynamic system, it also underscores the need for further research to establish a comprehensive and robust relational model between these factors. To this end, future research could aim to examine the causal links between the various factors of IOC, as well as the magnitude of their effects on one another. Specifically, such research could seek to identify the specific mechanisms through which these factors interact, including the mediating and moderating variables that may be at play. Additionally, the study could investigate how different contextual factors may shape the relationships between the various factors of IOC.

Author Contributions: Conceptualization, M.R.N.; methodology, M.R.N.; formal analysis, M.R.N.; investigation, M.R.N. and M.L.C.d.B.; resources, M.R.N. and H.L.M.B.; data curation, M.R.N., M.L.C.d.B., M.J.C.M.H. and H.L.M.B.; writing—original draft preparation, M.R.N.; writing—review and editing, M.R.N., M.L.C.d.B., M.J.C.M.H. and H.L.M.B.; supervision, M.L.C.d.B., M.J.C.M.H. and H.L.M.B.; project administration, M.R.N.; funding acquisition, M.J.C.M.H. and H.L.M.B. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by the Netherlands Organization for Scientific Research (NWO), grant number 439.16.804. The APC was funded by the Delft University of Technology.

Data Availability Statement: Some or all data that support the findings of this study are available from the corresponding author upon reasonable request.

Acknowledgments: This research was supported by Next-Generation Infrastructure (NGInfra) and the Netherlands Organization for Scientific Research (NWO).

Conflicts of Interest: The authors declare no conflict of interest.

Appendix A

Table A1. List of concourses based on three resources. The items highlighted in gray indicate the factors that were excluded from Q-set.

Number	Factors	Literature	Preliminary Research	Case Study	
1	Communication	x	x	x	3
2	Commitment	x	x	x	3
3	Common goal and shared vision	x	x	x	3
4	Collaborative leadership	x		x	2
5	Conflict resolution	x			1
6	Technical and substantive knowledge	x		x	2
7	Resource sharing	x	x	x	3
8	Trust	x	x	x	3
9	Equality	x	x	x	3
10	Clarify roles and responsibilities	x		x	2

Table A1. *Cont.*

Number	Factors	Literature	Preliminary Research	Case Study	
11	Relationship orientation	x		x	2
12	Organizational culture	x		x	2
13	Collaborative agreement	x	x	x	3
14	Collaborative tools	x		x	2
15	Adaptability	x		x	2
16	Teamwork and cooperation	x	x	x	3
17	Top management support	x	x	x	3
18	Early involvement of key participants	x	x	x	3
19	Respect	x	x	x	3
20	Willingness	x	x	x	3
21	Interpersonal understanding	x	x	x	3
22	Joint decision-making	x	x	x	3
23	Team building	x			1
24	Individual competency	x	x	x	3
25	Collaborative process	x	x	x	3
26	Regulations and government support	x	x		2
27	Internal administration of each organization	x			1
28	Team motivation and incentives	x			1
29	Share pain and gain	x	x		2
30	External communication	x			1
31	Group process skills	x			1
32	Compatibility of management styles	x			1
33	Unity (No organizational boundaries)	x	x	x	3
34	Time of inter-organizational collaboration	x			1
35	Physical proximity	x			1
36	Expectations of collaborating organizations	x			1
37	Alignment of incentives	x			1
38	Iteration of inter-organizational collaboration	x			1
39	Uncertainty conditions of collaborative work	x			1
40	Social and economic conditions	x			1
41	Openness		x	x	2
42	Safe environment		x	x	2
43	Getting to know each other		x	x	2
44	Having fun		x	x	2
45	Consistent team members		x		1
46	Awareness of each other work			x	1
47	Choosing the right/impactful people		x		1

Table A2. Identified factors of IOC based on the literature review.

Number	Factors of IOC Based on the Literature	Frequency [1]
1	Communication [19,20,29,31–33,35]	7
2	Commitment [19,20,28–31,34]	7
3	Common goal and shared vision [19,20,28–31]	6
4	Collaborative leadership [20,28,33–35]	5
5	Conflict resolution [19,20,28,30,35]	5
6	Technical and substantive knowledge [19,20,28,29,35]	5
7	Clarify roles and responsibilities [19,20,29–31]	5
8	Trust [19,20,28–30]	5
9	Organizational culture [19,20,31,34]	4
10	Resource sharing [19,20,28,34]	4
11	Relationship orientation [19,20,33,34]	4
12	Collaborative agreement [19,20,33,35]	4
13	Collaborative tools [19,20,28,33]	4
14	Adaptability [19,20,34,35]	4
15	Collaborative process [19,20,28]	3

Table A2. *Cont.*

Number	Factors of IOC Based on the Literature	Frequency [1]
16	Interpersonal understanding [20,34,35]	3
17	Teamwork and cooperation [20,28,34]	3
18	Top management support [19,20,28]	3
19	Early involvement of key participants [19,31,33]	3
20	Respect [20,29,35]	3
21	Willingness to collaborate [19,20,29]	3
22	Joint decision-making [20,28]	2
23	Equality [20,35]	2
24	Team building [20,28]	2
25	Individual competency [34,35]	2
26	Regulations and government support [20,29]	2
27	Team motivation and incentives [20,33]	2
28	Share pain and gain [19,29]	2
29	Expectations of collaborating [20,30]	2
30	External communication [29]	1
31	Group process skills [35]	1
32	Compatibility of management styles [28]	1
33	No organizational boundaries (unity) [31]	1
34	Time of inter-organizational collaboration [20]	1
35	Physical proximity [30]	1
36	Internal administration of each organization [20]	1
37	Social and economic conditions [20]	1
38	Iteration of inter-organizational collaboration [20]	1
39	Uncertainty conditions of collaborative work [20]	1
40	Equity [28]	1

[1] (The Frequency in the Table Represents the Number of Times a Specific Factor Was Mentioned).

Table A3. Identified factors of IOC based on the preliminary research.

Number	Factors of IOC Based on the Preliminary Research	Frequency [1]
1	Common goal and shared vision	9
2	Teamwork and cooperation	8
3	Openness	7
4	Interpersonal understanding	7
5	Collaborative agreement	6
6	Willingness	6
7	Resource sharing	5
8	Trust	5
9	Communication	5
10	Equality	5
11	Safe environment	5
12	Top management support	4
13	Commitment	4
14	Respect	4
15	Joint decision-making	4
16	Unity	3
17	Choosing the right/impactful people	3
18	Getting to know each other	3
19	Individual competency	3
20	Early involvement of key participants	2
21	Consistent team members	2
22	Regulations and government Support	2
23	Share pain and gain	2
24	Collaborative process	2
25	Having fun	2

[1] (The Frequency in the Table Represents the Number of Times a Specific Factor Was Mentioned).

Table A4. The identified factors of IOC based on case studies.

Number	Factors of IOC Based on the Case Study	Frequency [1]
1	Communication	13
2	Teamwork and cooperation	9
3	Resource sharing	9
4	Getting to know each other	8
5	Openness	7
6	Interpersonal understanding	7
7	Trust	6
8	Organizational culture	6
9	Collaborative tools	6
10	Equality	6
11	Collaborative agreement	5
12	Collaborative process	4
13	Common goal and shared vision	3
14	Individual competency	3
15	Early involvement of key participants	3
16	Safe environment	3
17	Willingness	3
18	Respect	3
19	Joint decision-making	3
20	Clarify roles and responsibilities	3
21	Adaptability	2
22	Commitment	2
23	Technical and substantive knowledge	2
24	Top management support	2
25	Unity	2
26	Awareness of each other work	2
27	Collaborative leadership	1
28	Relationship orientation	1
29	Having fun	1

[1] (The Frequency in the Table Represents the Number of Times a Specific Factor Was Mentioned).

Table A5. Z-score and Q-sort values for the two perspectives.

Number	Statement	Perspective 1		Perspective 2	
		Z-Score	Q-Score	Z-Score	Q-Score
1	Commitment	1.86	1	1.05	5
2	Respect among people	0.66	11	1.78	1
3	Willingness to collaborate	1.15	4	1.02	6
4	Interpersonal understanding	−0.12	21	0.88	7
5	Understanding the mutual expectations	0.85	9	1.37	3
6	Individual competency for collaborative tasks	0.65	12	−0.16	21
7	Professional and technical expertise of collaborators	0.29	17	−1.18	32
8	Previous inter-organizational collaboration experience	−1.27	32	−1.13	31
9	Getting to know each other	−1.10	29	0.31	17
10	Having fun	−0.43	24	0.74	10
11	Relationship building	−0.28	22	−0.08	19
12	Unity with no organizational boundaries	−1.37	34	−1.08	30
13	Early involvement of key participants	0.97	6	0.86	8
14	Reciprocated Trust	0.60	14	1.36	4
15	Openness	0.85	8	0.44	15
16	Adaptability	0.12	19	0.26	18
17	Common goal and shared vision	1.79	2	0.44	14
18	Inclusive coordination and teamwork	0.33	16	−0.23	24
19	Joint decision-making	0.61	13	−0.13	20
20	Management via a common collaborative process	−1.50	35	−0.66	26

Table A5. *Cont.*

Number	Statement	Perspective 1		Perspective 2	
		Z-Score	Q-Score	Z-Score	Q-Score
21	Equality between collaborating parties	−0.35	23	−1.70	35
22	Balanced relationship	−1.07	28	−0.87	28
23	Shared organizational culture	−1.29	33	−2.10	36
24	Understanding of different organizational culture	−0.80	26	0.62	12
25	Collaborative leadership	0.27	18	−0.18	22
26	Top management support	1.06	5	1.56	2
27	Frequent, high-quality, professional communication	0.92	7	0.52	13
28	Direct informal communication	1.18	3	−0.71	27
29	Safe environment	0.35	15	0.85	9
30	Resource sharing	−1.21	31	−0.91	29
31	Clear definition of roles and responsibilities	0.84	10	−0.58	25
32	Collaborative legal agreement	−1.02	27	−1.53	33
33	Collaborative common ground rules	−0.00	20	−0.23	23
34	Collaborative tools and technologies	−1.19	30	−1.57	34
35	Regulations and government support	−1.89	36	0.64	11
36	Share pain and gain	−0.48	25	0.34	16

References

1. Hertogh, M.J.; Bakker, J.D.; van der Vlist, M.J.; Barneveld, A.S. Life cycle management in upgrade and renewal of civil infrastructures. *Organ. Technol. Manag. Constr. Int. J.* **2018**, *10*, 1735–1746. [CrossRef]
2. Hall, J.W.; Henriques, J.J.; Hickford, A.J.; Nicholls, R.J.; Baruah, P.; Birkin, M.; Chaudry, M.; Curtis, T.P.; Eyre, N.; Jones, C.; et al. Assessing the long-term performance of cross-sectoral strategies for national infrastructure. *J. Infrastruct. Syst.* **2014**, *20*, 04014014.
3. Røsok, O.P.; de Bruijne, M.L.; Veeneman, W.W. Dealing with Cross-Sectoral Uncertainty: A Case Study on Governing Uncertainty for Infrastructures in Transition. *Sustainability* **2023**, *15*, 3750. [CrossRef]
4. Newell, S.; Swan, J. Trust and Inter-Organizational Networking. *Hum. Relat.* **2000**, *53*, 1287–1328. [CrossRef]
5. Hardy, C.; Phillips, N. Strategies of engagement: Lessons from the critical examination of collaboration and conflict in an interorganizational domain. *Organ. Sci.* **1998**, *9*, 217–230. [CrossRef]
6. Gray, B. *Collaborating: Finding Common Ground for Multiparty Problems*; Jossey-Bass Publishers: San Francisco, CA, USA, 1989.
7. Trist, E. Referent organizations and the development of inter-organizational domains. *Hum. Relat.* **1983**, *36*, 269–284. [CrossRef]
8. Stout, M.; Keast, R. Collaboration: What does it really mean? In *Handbook of Collaborative Public Management*; Edward Elgar Publishing: Cheltenham, UK, 2021; pp. 17–35.
9. Emmitt, S.; Ruikar, K. *Collaborative Design Management*; Routledge: Oxfordshire, UK, 2013.
10. Mason, R.; Lalwani, C.; Boughton, R. Combining vertical and horizontal collaboration for transport optimisation. *Supply Chain Manag. Int. J.* **2007**, *12*, 187–199. [CrossRef]
11. Franco, L.A. Facilitating collaboration with problem structuring methods: A case study of an inter-organisational construction partnership. *Group Decis. Negot.* **2008**, *17*, 267–286. [CrossRef]
12. Nezami, M.R.; de Bruijne, M.L.C.; Hertogh, M.J.C.M.; Bakker, H.L.M. Collaboration and Data Sharing in Inter-Organizational Infrastructure Construction Projects. *Sustainability* **2022**, *14*, 16835. [CrossRef]
13. Madhok, A.; Tallman, S.B. Resources, transactions and rents: Managing value through interfirm collaborative relationships. *Organ. Sci.* **1998**, *9*, 326–339. [CrossRef]
14. Thomson, A.M.; Perry, J.L. Collaboration processes: Inside the black box. *Public Adm. Rev.* **2006**, *66*, 20–32. [CrossRef]
15. Hardy, C.; Lawrence, T.B.; Grant, D. Discourse and collaboration: The role of conversations and collective identity. *Acad. Manag. Rev.* **2005**, *30*, 58–77. [CrossRef]
16. Nezami, M.R.; Bertello, A.; Ståhle, M. Identifying the key challenges of Inter-organizational collaboration. In Proceedings of the EURAM Conference Leading Digital Transformation, Winterthur, Switzerland, 15–17 June 2022.
17. Raišienė, A.G.; Korsakienė, R.; Lace, N. How do inter-institutional teams succeed? *A case of national project. Econ. Sociol.* **2015**, *8*, 7–18.
18. Foster-Fishman, P.G.; Salem, D.A.; Allen, N.A.; Fahrbach, K. Facilitating interorganizational collaboration: The contributions of interorganizational alliances. *Am. J. Community Psychol.* **2001**, *29*, 875–905. [CrossRef]
19. Faris, H.; Gaterell, M.; Hutchinson, D. Investigating underlying factors of collaboration for construction projects in emerging economies using exploratory factor analysis. *Int. J. Constr. Manag.* **2022**, *22*, 514–526. [CrossRef]
20. Kożuch, B.; Sienkiewicz-Małyjurek, K. Factors of effective inter-organizational collaboration: A framework for public management. *Transylv. Rev. Adm. Sci.* **2016**, *47*, 97–115.
21. Saukko, L.; Aaltonen, K.; Haapasalo, H. Inter-organizational collaboration challenges and preconditions in industrial engineering projects. *Int. J. Manag. Proj. Bus.* **2020**, *13*, 999–1023. [CrossRef]

22. Akintoye, A.; McIntosh, G.; Fitzgerald, E. A survey of supply chain collaboration and management in the UK construction industry. *Eur. J. Purch. Supply Manag.* **2000**, *6*, 159–168. [CrossRef]
23. Simatupang, T.M.; Sridharan, R. An integrative framework for supply chain collaboration. *Int. J. Logist. Manag.* **2005**, *16*, 257–274. [CrossRef]
24. Akintoye, A.; Main, J. Collaborative relationships in construction: The UK contractors' perception. *Eng. Constr. Archit. Manag.* **2007**, *14*, 597–617. [CrossRef]
25. Suprapto, M.; Bakker, H.L.; Mooi, H.G. Relational factors in owner–contractor collaboration: The mediating role of teamworking. *Int. J. Proj. Manag.* **2015**, *33*, 1347–1363. [CrossRef]
26. McHugh, N.; Baker, R.; Biosca, O. Who knows best? AQ methodology study to explore perspectives of professional stakeholders and community participants on health in low-income communities. *BMC Health Serv.* **2019**, *19*, 35.
27. Stenner, P.; Watts, S.; Worrell, M. Q methodology. In *The SAGE Handbook of Qualitative Research in Psychology*; SAGE Publications Ltd.: Thousand Oaks, CA, USA, 2008; pp. 215–239.
28. Verdecho, M.-J.; Alfaro-Saiz, J.-J.; Rodriguez-Rodriguez, R.; Ortiz-Bas, A. A multi-criteria approach for managing inter-enterprise collaborative relationships. *Omega* **2012**, *40*, 249–263. [CrossRef]
29. Jacobson, C.; Choi, S.O. Success factors: Public works and public-private partnerships. *Int. J. Public Sect. Manag.* **2008**, *21*, 637–657. [CrossRef]
30. Dietrich, P.; Eskerod, P.; Dalcher, D.; Sandhawalia, B. The Dynamics of Collaboration in Multipartner Projects. *Proj. Manag. J.* **2010**, *41*, 59–78. [CrossRef]
31. Smith, E.M.; Thomasson, A. The use of the partnering concept for public–private collaboration: How well does it really work? *Public Organ. Rev.* **2018**, *18*, 191–206. [CrossRef]
32. Savolainen, J.M.; Saari, A.; Männistö, A.; Kähkonen, K. Indicators of collaborative design management in construction projects. *J. Eng. Des. Technol.* **2018**, *16*, 674–691. [CrossRef]
33. Sujan, S.; Jones, S.W.; Kiviniemi, A.; Wheatcroft, J.M.; Mwiya, B. Holistically assessing collaborative culture in the AEC industry. *J. Inf. Technol. Constr.* **2020**, *25*, 272–286. [CrossRef]
34. Getha-Taylor, H. Identifying collaborative competencies. *Rev. Public Pers. Adm.* **2008**, *28*, 103–119. [CrossRef]
35. O'Leary, R.; Choi, Y.; Gerard, C.M. The Skill Set of the Successful Collaborator. *Public Adm. Rev.* **2012**, *72*, S70–S83. [CrossRef]
36. McKeown, B.; Thomas, D.B. *Q Methodology*; Sage Publications: Thousand Oaks, CA, USA, 2013; Volume 66.
37. Brown, S.R. A Primer on Q Methodology. *Operant. Subj.* **1993**, *16*, 26. [CrossRef]
38. Foster-Fishman, P.G.; Berkowitz, S.L.; Lounsbury, D.W.; Jacobson, S.; Allen, N.A. Building Collaborative Capacity in Community Coalitions: A Review and Integrative Framework. *Am. J. Community Psychol.* **2001**, *29*, 241–261. [CrossRef] [PubMed]
39. Watts, S.; Stenner, P. *Doing Q Methodological Research: Theory, Method and Interpretation*; SAGE Publications Ltd.: London, UK, 2012.
40. Webler, T.; Danielson, S.; Tuler, S. Using Q Method to Reveal Social Perspectives in Environmental Research. *Greenfield MA Soc. Environ. Res. Inst.* **2009**, *54*, 1–45.
41. Den Otter, A.; Emmitt, S. Design team communication and design task complexity: The preference for dialogues. *Archit. Eng. Des. Manag.* **2008**, *4*, 121–129. [CrossRef]
42. Huxham, C.; Vangen, S. Leadership in the shaping and implementation of collaboration agendas: How things happen in a (not quite) joined-up world. *Acad. Manag. J.* **2000**, *43*, 1159–1175. [CrossRef]
43. Phillips, N.; Lawrence, T.B.; Hardy, C. Inter-organizational collaboration and the dynamics of institutional fields. *J. Manag. Stud.* **2000**, *37*, 23–43. [CrossRef]
44. Kooiman, J. *Governing as Governance*; Sage: London, UK, 2003.
45. Savelsbergh, C.; Storm, P. Building and leading the team. In *Management of Engineering Projects: People are Key*; NAP—The Process Industry Competence Network: Nijkerk, The Netherlands, 2014; pp. 65–85.
46. Sirmon, D.G.; Lane, P.J. A model of cultural differences and international alliance performance. *J. Int. Bus. Stud.* **2004**, *35*, 306–319. [CrossRef]
47. Suprapto, M. Collaborative Contracting in Projects. Ph.D. Dissertation, Delft University of Technology, Delft, The Netherlands, 2016.