Master Thesis

Stakeholder Perspectives on Interventions for Up-Scaling the Procurement of Circular Viaducts and Bridges

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by

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Preface

This master thesis identifies stakeholder perspectives on interventions required to upscale the procurement of circular viaducts and bridges. The topic combines my interests in circularity and procurement and is particularly exciting because of the many developments currently taking place in this area. These developments made the research both challenging and rewarding, as new ideas and practices continued to emerge during my thesis process. This thesis also wraps up my time as a student in Delft, which began just over five years ago.

A big thank you to Witteveen+Bos for the opportunity to conduct my thesis research with them. Working there provided valuable exposure to professional life and helped me see how research connects to practice. I am also thankful to the professionals who are actively working on circular viaducts and bridges. Attending events and networking with experts in this field was a source of motivation, as it showed the enthusiasm and commitment of so many people, to the topic I was researching. Their passion for circular infrastructure inspired me throughout this process. I would also like to extend my gratitude to those who participated in my Q-sort interviews. Their enthusiasm and willingness to engage led to many interesting and valuable conversations that greatly enriched this thesis.

This thesis would not have been possible without the support of my graduation committee. From the university, I would like to thank Leon Hombergen, thank you for your guidance from the very beginning and for always offering helpful perspectives when I faced challenges. Maedeh Molaei, I truly appreciate your consistent advice, support, and readiness to answer questions whenever needed. Daan Schraven, thank you for your critical feedback, which not only pushed me to analyze my work from different angles but also helped me refine the structure and improve the overall quality of my research. At Witteveen+Bos, Jesper Pots and Michiel Mulder, thank you for your incredible support throughout this process. I really appreciated our weekly collaboration days, your regular check-ins, and your constant availability for questions. The enjoyable activities outside of work also made this journey all the more enjoyable.

Lastly, I would like to thank my family, friends, and colleagues at Witteveen+Bos for their support during this journey. Whether by listening to my thoughts, discussing my ideas, or helping me unwind when needed, their encouragement made all the difference.

I hope you enjoy reading my thesis.

Niels Rebers
Delft, November 2024

Executive Summary

The depletion of natural resources and the rise in carbon emissions are accelerating globally, as highlighted in recent climate reports (Ripple et al., 2024). Circular Economy (CE) principles, which promote resource efficiency and waste reduction, offer a contribution to a vital solution for this depletion and acceleration in carbon emissions. In the Netherlands, where the government aims to achieve full circularity by 2050, the infrastructure sector presents an important sector due their material and carbon emissions intensive activities. A major contribution in the infrastructure sector are viaducts and bridges, contributing to 25% of the CO2 emissions and materials demand in the Dutch Ground, Road, and Waterworks (GWW) sector, which provides an opportunity to reduce environmental impact if public authorities apply circular procurement practices (EU, 2017).

Despite this opportunity, applying and scaling circular procurement for viaducts and bridges faces several challenges. These include risk-averse procurement practices, fragmented knowledge, and limited collaboration both between public contracting authorities and the market, as well as among the public contracting authorities themselves. While initiatives like the SBIR Circular Viaducts or Buyer Group have led to innovative solutions, broad adoption of these solutions remains limited. Tom Coenen's recent dissertation on institutional logics and transitional barriers within the infrastructure sector, highlights the complexity of aligning procurement practices with broader circularity goals (Coenen, 2024). This research aimed to explore key stakeholder perspectives on interventions that could help scale procurement for circular viaducts and bridges. By gathering insights from public contracting authorities, market participants involved in SBIR Circular Viaducts, and knowledge institutions, this study sought to answer the following main research question:

> *"What are the different perspectives of key stakeholders on the interventions needed to upscale the procurement of circular bridges and viaducts by public contracting authorities?"*

To achieve this, the research employed Q-methodology, a research method for capturing subjective viewpoints. Given that the literature on Circular Public Procurement (CPP) is not specifically tailored to infrastructure, the initial set of 17 interventions identified from the literature was expanded with 31 additional interventions derived from empirical research specific to circular viaducts and bridges. Two expert interviews helped refine this concourse to a Q-set of 25 interventions. The Q-sort was conducted with 14 participants, in which they were asked to rank these interventions. Participants were chosen from Rijkswaterstaat (the executive organization of the Dutch Ministry of Infrastructure and Water Management), provinces, municipalities, market parties, and knowledge institutions, all with relevant experience in circular viaducts and bridges projects.

The main findings of the Q-sort analysis revealed four distinct perspectives. These four perspectives and their key insights are summarized in table 1.

Table 1: Overview of the four perspectives and their key insight

	Practical Circularity	**Collaborative Circularity**	**Tactical Circularity**	**Financially-Driven Circularity**
Description	Focuses on immediate, actionable solutions such as flexible regulations and logistics.	Emphasizes leadership, collaboration, and shared responsibility across sectors.	Centres on structured processes, standardization, and internal coordination for scaling circular practices.	Highlights the use of financial mechanisms, such as incentives and penalties, to drive circular procurement.

	Practical Circularity	Collaborative Circularity	Tactical Circularity	Financially-Driven Circularity
Key Insight	Practical interventions address short-term barriers and facilitate immediate progress while creating a foundation for integrating broader strategic changes.	Collaboration and leadership are necessary to bridge resource gaps and build partnerships, especially for smaller public authorities.	Clear and consistent frameworks are critical to align stakeholders, streamline processes, and embed circularity into organizational practices.	Financial strategies create market-driven incentives for circular procurement, emphasizing the economic viability of circular practices.

The findings show that key stakeholders understand the necessary steps for advancing circular procurement, but the focus must now shift to implementation. Interventions like the portfolio and program approach are universally viewed as effective and should be prioritized, while knowledge-sharing is seen as less critical. Smaller public authorities, such as provinces and municipalities, seek stronger partnerships, and standardization can help bring these entities into circular procurement frameworks. However, tensions may arise between stakeholders advocating for standardization and those pushing for flexibility. While this study, using Q-methodology, provides an overview of perspectives rather than definitive solutions, it highlights the potential for aligning specific roles within the procurement process to address these tensions. Additionally, the perspectives identified could inform strategies that explore how short-term, action-oriented solutions and longer-term strategic approaches might coexist to improve collaboration and reduce conflicts among diverse stakeholder groups.

This research contributes to the literature on CPP by providing an inventory of interventions for up-scaling the procurement of circular viaducts and bridges, integrating theoretical insights with empirical evidence. While much of the existing literature emphasizes knowledge dissemination, this study highlights stakeholders' stronger preference for practical, action-oriented solutions. To interpret the findings, Tom Coenen's work on institutional logics was applied to clarify and contextualize the different perspectives. This helped identify the presence of multiple logics, such as project, sustainability, and asset management logics. While also uncovering nuances, including the prominence of community logic among smaller public authorities.

Future research should broaden the scope by incorporating a more diverse sample of stakeholders, including those from varied functional roles and levels of experience, especially individuals with limited exposure to circularity. Such an approach would enrich the understanding of the dynamics within CPP. Longitudinal studies could track the evolution of stakeholder perspectives over time, offering insights into how developments and market conditions shape the scaling of circular procurement. Moreover, there is a need for focused research on the challenges and opportunities faced by smaller public authorities, such as municipalities and provinces, particularly regarding their resource limitations and reliance on partnerships.

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1

Introduction

In a period where preventing the depletion of natural resources has become an undeniable challenge, the need for sustainable solutions is more critical than ever. Ripple et al. (2024) in a recent climate report underscore this urgency, highlighting that the depletion of natural resources and associated carbon emissions are accelerating globally, while the amount of waste and pollution continues to grow at alarming rates. To address this global necessity, transitioning to a circular economy is crucial, as it promises to minimize waste, reduce environmental impacts, and extend the life-cycle of resources (Velenturf & Purnell, 2021). As Kirchherr et al. (2017) illustrates, the circular economy has been defined in various ways, but all definitions share a common goal: to make better use of resources and reduce environmental harm. Therefore, adopting circular practices is essential to halt resource depletion and drive towards a more sustainable future.

Recognizing this global necessity, the Dutch government is committed to achieving a fully circular economy in the Netherlands by 2050 (Ministerie van Infrastructuur en Waterstaat, 2024). To support this ambition, in 2023, the National Programme Circular Economy (NPCE) was initiated, outlining measures for more efficient use of resources in the forthcoming years (Ministerie van Infrastructuur en Waterstaat, 2023a). Furthermore, the Ministry of Infrastructure and Water Management has set even more ambitious goals, aiming for complete circularity and carbon neutrality by 2030 (Ministerie van Infrastructuur en Waterstaat, 2016). This strategy is not limited to the government itself; Rijkswaterstaat, the executive agency under the Ministry of Infrastructure and Water Management, expects its contractors and suppliers to adopt these circular goals as well. Achieving such an ambitious transition requires strong political support and regulatory frameworks. Additionally, the Circular Economy Report (ICER) emphasizes that achieving these goals will require the introduction of more mandatory policies (Planbureau voor de Leefomgeving, 2023).

Acknowledging this goal, the construction industry is making significant strides in transitioning to a circular economy. This sector is crucial in the move towards sustainability, given that it is responsible for over 30% of the extraction of natural resources and 23,5% of solid waste generated in The Netherlands (CBS, 2019). Recognizing its impact, the construction industry is striving to define and implement circularity uniformly. This effort has led to the creation of 'Het Nieuwe Normaal,' a new standard for circular construction with ambitious performance goals for buildings, infrastructure, and areas (Normaal, 2023).

A notable challenge in the Dutch construction industry is the vast number of civil assets, including approximately 85,000 viaducts and bridges, 3,000 tunnels, and 2,000 locks (Infrastructuur en Waterstaat, 2023). In 2017, these structures contributed to 1,000 kton of CO_2 emissions (Infrastructuur en Waterstaat, 2023), representing 25% of the total emissions in the Dutch ground, road, and waterworks (GWW) sector (CROW, 2023). Given these figures, focusing on integrating circular principles into the procurement of viaducts and bridges presents a significant opportunity to reduce the environmental impact of the construction industry.

The integration of circular principles into the construction sector is not yet mainstream or widely adopted (Adams et al., 2017). An important factor in integrating circular principles into the construction industry is circular public procurement. Focusing on procurement is crucial for driving demand for circular products and services (EU, 2024). However, circular public procurement remains an emerging field with significant barriers to overcome (Sönnichsen & Clement, 2020).

One of the ways Rijkswaterstaat is working to integrate circular principles into the procurement of civil structures is through innovative procurement methods aimed at developing new knowledge and innovations in collaboration with the market. To this end, Rijkswaterstaat implemented the Strategic Business Innovation Research (SBIR) program for circular viaducts. This initiative generated numerous innovative ideas for building circular viaducts and bridges (Ministerie van Infrastructuur en Waterstaat, 2021). However, as the SBIR program nears completion, there remains uncertainty about how these innovative solutions can be broadly applied, not only within Rijkswaterstaat but also across municipalities and provinces. Notably, only 1,114 bridges (1.3%) are owned by Rijkswaterstaat (Ministerie van Infrastructuur en Waterstaat, 2023b), highlighting the significant responsibility of municipalities and provinces in implementing these solutions. Therefore, the primary objective of this research is to gain insights into the perspectives of key stakeholders, including those from public contracting authorities, market parties, and knowledge institutions, on interventions that could improve the up-scaling of the procurement of circular bridges and viaducts. Interventions are defined as “a purposeful and planned action taken by individuals or organizations to address a particular situation, problem, or challenge” (Zhang & Chowdhury, 2024).

1.1. Context

The National Programme Circular Economy 2023-2030 (NPCE) outlines the Netherlands’ goal to be fully circular by 2050. This program sets objectives to reduce resource use, extend product lifespans, and improve recycling. In the infrastructure sector, viaducts and bridges are key areas of focus due to their significant use of materials and impact on the environment. The NPCE aims to reduce the environmental footprint of these structures by 2030 by applying circular design and practices throughout their lifecycle.

To meet these goals, the Ministry of Infrastructure and Water Management developed the Transitiepad Kunstwerken strategy, targeting circular civil structures by 2030. This strategy emphasizes sustainable design, construction, and maintenance for viaducts and bridges. Key elements include reusing materials and ensuring the longevity of these structures.

One of the tools to drive innovation is through Small Business Innovation Research (SBIR). Through this initiative, Rijkswaterstaat has sought innovative solutions to create circular viaducts. The SBIR Circular Viaducts program, launched in 2020, challenged market participants to develop new concepts for circular viaducts. The program led to the selection of three consortia that continue to develop and prototype these concepts. Each consortium’s progress and impact are discussed in more detail in appendix A.

The Buyer Group Circular Viaducts and Bridges, established in 2021, works to support public sector clients in aligning their procurement processes with circular economy principles. The group collaborates with experts and market players to standardize approaches and promote circular procurement. However, scaling the procurement of circular viaducts and bridges remains a challenge, requiring further coordination and commitment.

For a detailed explanation of the research context, please refer to Appendix A.

1.2. Problem Definition

This section defines the problem by examining the current situation and the challenges in transitioning innovations from the SBIR Circular Viaducts program to widespread application. It discusses the issues identified by public clients and the market, as well as the efforts made by the buyer group Circular Viaducts and Bridges. The section concludes with a detailed problem statement, emphasizing the need for academic research to address the fragmented understanding and interventions for up-scaling of circular viaducts and bridges.

1.2.1. Problem Identification

While the SBIR Circular Viaducts has pioneered innovative concepts, scaling these to a larger market requires organizational support and the restructuring of work processes, which is difficult due to a risk-averse culture focused on deadlines and budgets (Rijkswaterstaat, 2024). Although SBIR fosters innovation, widespread adoption needs a different approach—one that includes setting realistic expectations and clearly outlining steps for broader implementation (Rijkswaterstaat, 2024).

Public clients, especially the buyer group Circular Viaducts and Bridges, have identified two key challenges: reusing existing structures and creating new ones using sustainable materials (Group, 2024). These challenges were addressed by SBIR prototypes, such as 'Closing the Loop' and 'ViCi,' which focused on recycling and modular construction. With around 85,000 bridges and viaducts in the Netherlands, of which only a small portion are owned by Rijkswaterstaat, the majority of this responsibility lies with municipalities and provinces, highlighting the urgency for innovative solutions (Rijkswaterstaat et al., 2022). Moreover, about 70% of civil structures are dismantled before their lifespan ends, further emphasizing the need for strategies that incorporate reuse and modular design (Trommel, 2024).

The buyer group advocates for active participation from clients in organizing reuse and the creation of new circular infrastructure (Group, 2024). This requires not just market solutions but also shifts in procurement processes, including enhanced collaboration, transparency, and capacity building among contracting authorities to effectively implement circular principles (van Efferen, 2024). Additionally, the varying levels of experience among public contracting authorities make it difficult to standardize solutions, indicating a need for a structured overview of stakeholder perspectives to identify differences and build consensus (Raadgever et al., 2008).

Market Perspective

While public clients face challenges, the market has additional barriers that complicate the transition to circular construction. These include the low cost of virgin materials, inadequate asset valuation that neglects circularity, and the need for a better understanding of risks associated with circular innovations (WBCSD, 2018). High initial investments and limited market volume for innovative circular products further complicate the transition (Adams, 2021; WBCSD, 2018). Overcoming these challenges requires market participants—contractors, manufacturers, and suppliers—to adapt to circular principles and clearly communicate their economic, environmental, and social benefits to encourage broader adoption.

1.2.2. Problem Statement

As the SBIR program on circular viaducts approaches completion, with prototypes in development, a significant challenge emerges in transitioning these innovations from concept to widespread application. Particularly in a context of the Netherlands with its extensive infrastructure of 85,000 bridges and viaducts. Widespread adoption faces hurdles due to the existing procurement processes, risk-averse culture, and the need for a shift towards collaborative, transparent practices that embrace circular solutions. Additionally, the emphasis should extend beyond Rijkswaterstaat, particularly to municipalities and provinces, as they own more than 80% of the bridges and viaducts in the Netherlands (VNG, 2024).

While initiatives like the Buyer Group are working to develop strategies to address these barriers, the knowledge and experience in implementing effective interventions remain inconsistent across stakeholders. This fragmentation highlights the need for academic research to compile and analyze the range of potential interventions. By presenting these interventions to stakeholders and gathering their perspectives, this research can offer valuable insights to support the up-scaling of procurement of circular viaducts and bridges.

1.3. Research Objective

The primary objective of this research is to identify and gain insights on the views of key stakeholders regarding the interventions that could improve the up-scaling of the procurement of circular bridges and viaducts. For the purposes of this study, key stakeholders are defined as individuals from three main stakeholder groups—public contracting authorities, market participants, and knowledge

institutions—who have direct experience with circular viaducts and bridges. This study aims to systematically gather potential interventions and understand the perspectives of these stakeholders.

Utilizing Q methodology, a research method used to study people's subjective experiences and viewpoints, this study seeks to identify and analyze the diverse views of these stakeholders concerning the implementation of interventions that can support circular public procurement practices.

The ultimate goal is to contribute to the broader transition towards a fully circular economy in the Netherlands by 2050, aligning with Rijkswaterstaat's targets for circularity and carbon neutrality by 2030. By compiling interventions and presenting them to stakeholders, this research aims to increase awareness of the diverse viewpoints, facilitate further discussion, and guide the future development of interventions for up-scaling circular procurement practices in the infrastructure sector.

1.4. Research Scope

This research focuses on the shift needed within public contracting authorities to improve the upscaling of the procurement of circular bridges and viaducts. While the primary emphasis is on the changes required on the public contracting authority side, the study incorporates the views of public contracting authorities, market participants, and knowledge institutions to gain a comprehensive understanding.

The perspectives of public contracting authorities, including Rijkswaterstaat, as well as provincial and municipal governments, are examined. The involvement of municipalities and provinces is crucial, as these local and regional governments manage the majority of bridges and viaducts in the Netherlands. Their role is essential for the up-scaling and widespread application of circular economy principles. Additionally, the market perspective is drawn from the three final consortia of the SBIR Circular Viaducts initiative, emphasizing both reuse and modularity aspects of circularity. Insights from knowledge institutions are also considered to enrich the analysis.

By investigating the barriers and interventions identified in literature, while systematically gathering and analyzing the interventions already recognized in empirical research, the study aims to provide a comprehensive view of the interventions that could enhance the procurement of circular viaducts and bridges.

1.5. Research Questions

To achieve the previously outlined objectives and scope, the main research question has been formulated as follows:

> *What are the different perspectives of key stakeholders on the interventions needed to upscale the procurement of circular bridges and viaducts by public contracting authorities?*

To address the main research question, four sub-research questions have been developed. The detailed steps of the research to answer these questions is discussed in chapter 1.8.

SQ 1 *What are the barriers applying circular public procurement by public contracting authorities and which interventions can be drawn from this?*

> The barriers and interventions for circular public procurement will be identified through a literature review.

SQ 2 *How can Q-methodology be applied to capture the perspectives of key stakeholders on the interventions for upscaling circular procurement?*

> The varying perspectives of stakeholders will be collected and analyzed through the application of Q-methodology, employing both quantitative and qualitative analysis.

SQ 3 *What interventions for upscaling the procurement of circular bridges and viaducts can be identified through a document review?*

> The second set of interventions will be gathered through a document review of relevant initiatives and reports.

SQ 4 *How do the identified perspectives of the key stakeholders compare, and what insights can be drawn?*

Following the identification of stakeholder perspectives, the differences and similarities will be examined, resulting in recommendations that address the main research question.

1.6. Research Method: Q-Methodology

Q-methodology, developed by William Stephenson in the 1930s, is a research approach that combines qualitative and quantitative methods to explore subjective viewpoints. It is particularly effective in studying the range of opinions individuals hold on a given topic, especially when those views are complex and not easily quantifiable (Brown, 1993; Stephenson, 1953).

In Q-methodology, participants rank a series of statements (the ”Q-set”), which are drawn from a larger body of possible opinions or ideas known as the ”Concourse”. The participants, referred to as the ”P-set”, are selected to represent a variety of perspectives on the subject. During the ”Q-sort”, participants rank these statements according to their level of agreement or importance. The rankings are then analyzed using statistical techniques like factor analysis to identify groups of participants who share similar viewpoints. This allows researchers to map out clusters of opinions without prior assumptions about what those opinions might be. Unlike traditional surveys, Q-methodology emphasizes understanding the subjective meanings individuals assign to different statements, enabling deeper insight into their viewpoints.

The strength of Q-methodology lies in its ability to capture subjective perspectives in a structured way. Participants react to the same set of statements, which allows for direct comparison of responses and reduces the potential for researcher bias (Brouwer, 1999). The method focuses on participants' subjective rankings, minimizing the influence of interviewer interactions or open-ended questions. Furthermore, it is well-suited to smaller sample sizes, making it ideal for in-depth studies where the number of respondents may be limited but the goal is to explore deep, subjective insights.

Q-methodology has been successfully applied in various studies. For example, Kornevs et al. (2016) used it to analyze stakeholder views on innovative procurement, while D'amato et al. (2019) applied it to explore researchers' opinions on sustainability models. These studies highlight how Q-methodology can capture the subjective views of different stakeholders, making it suitable for this research.

In this study, Q-methodology is employed to identify and gain insights into the views of stakeholders on interventions for upscaling the procurement of circular viaducts and bridges. Its ability to reveal patterns of agreement and disagreement among stakeholders ensures that the study's recommendations are grounded in diverse, real-world perspectives.

1.7. Societal & Theoretical Relevance

Societal relevance

The transition towards a circular economy is a global effort aimed at conserving natural resources, reducing waste, and mitigating environmental impacts. This research focuses on understanding the perspectives of stakeholders on interventions for up-scaling procurement of circular bridges and viaducts. By capturing diverse viewpoints, it aims to raise awareness, facilitate further discussion, and guide future development.

The initial reason for this research was the challenge identified within the SBIR program on circular viaducts, which is nearing completion and faces difficulties in scaling innovative prototypes from concept to widespread application. Addressing these challenges is essential not only for Rijkswaterstaat, who initiated the program, but also for municipalities and provinces that own the majority of these infrastructures. By identifying stakeholders' views and effective interventions, this research aims to overcome barriers in existing procurement processes and promote collaborative and transparent practices that embrace circular solutions.

The study aligns with broader sustainability goals, including the Netherlands' ambition to transition to a fully circular economy by 2050. The insights gained will help public contracting authorities address the challenges of up-scaling circular procurement, contributing to a circular future by 2030.

Theoretical relevance

This research draws on insights from Coenen et al. (2022), addressing a gap in the scientific debate on circular economy transitions by examining the role of public contracting authorities in fostering market creation for circular innovations. Coenen's research highlights that, while there has been experimentation with circular procurement, these efforts often remain limited to a few innovative projects and struggle to integrate into conventional procurement structures.

Furthermore, this research references institutional logics frameworks as a lens to understand how different belief systems influence stakeholder perspectives in circular procurement. This builds on Coenen's exploration of these logics in the infrastructure sector (Coenen et al., 2024). By interpreting how these logics shape stakeholders' views, rather than focusing on decision-making processes, this study will identify both facilitators and barriers within current practices.

While previous literature has often focused on the knowledge gaps and theoretical barriers to CPP, this research provides a more up-to-date view on the interventions required to upscale circular procurement of bridges and viaducts. By connecting theoretical concepts with practical interventions, this study aims to not only advance academic understanding of circular procurement, but also offer actionable strategies that can drive real-world change. This dual impact ensures that the research remains relevant to both scholars and practitioners, creating a deeper integration of circular principles in infrastructure procurement.

1.8. Research Design and Outline

To achieve the research objective, the study is structured into seven chapters. Refer to the research design flowchart in Figure 1.1 for a detailed overview of the study's structure. The following paragraphs provide a description of each chapter

Chapter 2: Introduction

This chapter establishes the theoretical foundation, defining the circular economy (CE) and its relevance to infrastructure. It then focuses on Circular Public Procurement (CPP) and the barriers to its adoption. Finally, the chapter introduces institutional logics, which help explain how different belief systems influence decision-making in infrastructure procurement.

Chapter 3: Methodology

This chapter outlines the research methodology, focusing on Q-methodology to explore subjective perspectives. It explains the development of the concourse, the selection of the Q-set and P-set, and the Q-sort process. It ends with the describing of the statistical analysis methods, to show how perspectives will be identified.

Chapter 4: Results

This chapter presents the outcomes of the Q-sort, summarizing the development of the concourse, Q-set, and the selection of the P-set. The main focus is on analyzing the collected data to identify correlations and perspectives. In order for results interpretation in the next chapter.

Chapter 5: Interpretation of Results

This chapter interprets the identified perspectives, and compares them with each other. It describes the non-loader, consensus statements, and missing interventions. The chapter also explores how function groups and experience, shape the identified perspectives.

Chapter 6: Discussion

This chapter contextualizes the findings within the existing literature, contrasting theoretical-based versus empirical-based interventions. It also examines how institutional logics are connected to the perspectives. The chapter also discusses missed interventions, the contribution of this research to the field, and the research limitations.

Chapter 7: Conclusion

This chapter summarizes the findings and answers the main research question. It provides practical recommendations for enhancing the up-scaling of circular procurement and suggests areas for future research.

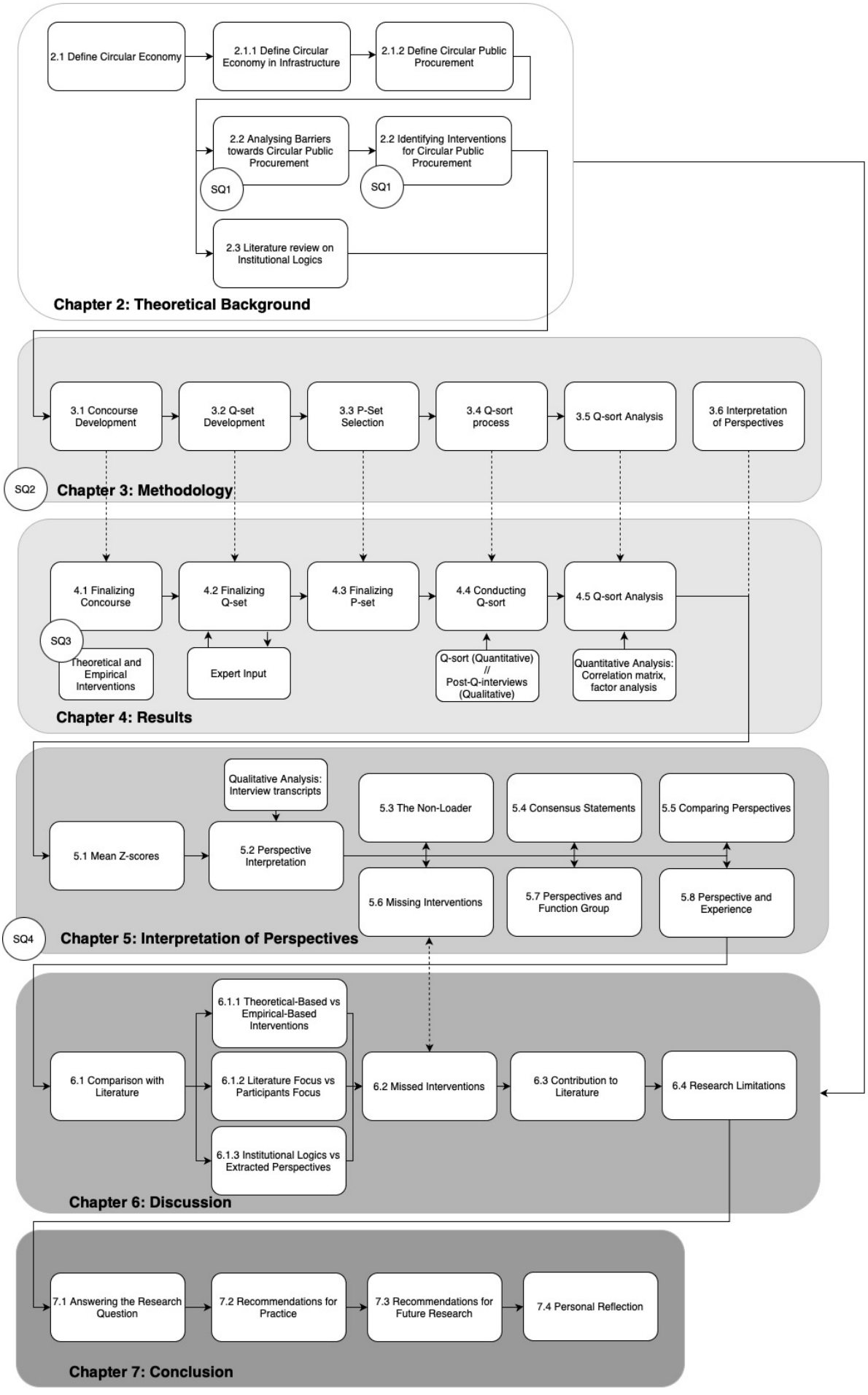

Figure 1.1: Research Design Flowchart

2

Theoretical background

This chapter provides the theoretical framework for understanding the core themes of this thesis. Section 2.1 introduces the concept of the circular economy (CE), focusing on key definitions and frameworks, like the 9R framework and its application in infrastructure. Section 2.2 reviews the limitations and interventions identified in the literature that support the scaling of Circular Public Procurement (CPP). Section 2.3 discusses institutional logics, which help explain the different belief systems influencing decision-making in infrastructure. These sections lay the groundwork for analyzing stakeholder perspectives in the subsequent chapters.

2.1. Circular Economy

The concept of CE has been extensively studied, leading to the development of over 200 definitions in literature (Plebankiewicz, 2022). This diversity opens the door for potential misinterpretation of the term. For the purposes of this research, the definition provided by Nobre and Tavares (2021) will be used, which was established by globally consulting CE experts:

> *"Circular Economy is an economic system that targets zero waste and pollution throughout materials lifecycles, from environment extraction to industrial transformation, and to final consumers, applying to all involved ecosystems. Upon its lifetime end, materials return to either an industrial process or, in case of a treated organic residual, safely back to the environment as in a natural regenerating cycle. It operates creating value at the macro, meso and micro levels and exploits to the fullest the sustainability nested concept. Used energy sources are clean and renewable. Resources use and consumption are efficient. Government agencies and responsible consumers play an active role ensuring correct system long-term operation." (Nobre & Tavares, 2021)*

To better understand and apply CE principles, it is helpful to first consider the foundational 3R framework, which stands for Reduce, Reuse, and Recycle. The 3R framework is widely recognized and developed in earlier sustainability models. Focusing on minimizing waste by encouraging the reduction of resource use, the reuse of materials, and the recycling of waste back into the production cycle (Ghisellini et al., 2016; Yang et al., 2014).

However, as the CE concept has evolved, it has become clear that a more comprehensive approach is needed. This led to the development of the 9R framework (Kirchherr et al., 2017), which expands on the 3R model by including additional strategies such as Refuse, Repair, Refurbish, Remanufacture, Repurpose, and Recover. The 9Rs form a hierarchy, with ”Refuse” being the most impactful in terms of preventing waste and ”Recover” being the least, focusing on extracting energy from materials that can no longer be reused or repurposed. This expanded framework allows for a more detailed and structured approach to circularity. Highlighting the importance of maintaining products and materials in use for as long as possible before resorting to recovery or disposal. The 9R's are displayed in table 2.1.

2.1.1. Circular Economy in Infrastructure

The construction industry is one of the largest consumers of resources and a major contributor to waste generation, making the adoption of CE principles a critical aspect of sustainability in this sector (Benachio et al., 2020). Despite the increasing body of research on CE, the infrastructure sector, particularly public infrastructure, has seen slower adoption of these principles. Mhatre et al. (2021) highlight that the inherent complexity and longevity of infrastructure assets, such as roads, bridges, and viaducts, pose unique challenges. Unlike products with shorter life cycles, infrastructure is designed to last for decades, complicating the integration of circular strategies. Additionally, much of the existing CE literature focuses on private sector innovations, leaving public sector applications, including infrastructure, relatively underexplored (Coenen et al., 2022; Klein et al., 2022). This gap has significant implications for how CE principles are implemented in large-scale public projects.

To address the unique challenges of infrastructure, the 9R framework (see Table 2.1) offers a model for embedding circularity into construction, operation, and maintenance processes. While the 9R framework encompasses strategies from Refuse (R0) to Recycle (R8), this research specifically focuses on Reuse (R3) as the relevant principle for circular infrastructure, for the current context of viaducts and bridges.

Reuse involves repurposing materials and components from decommissioned infrastructure for new projects without significant alteration. This contrasts with recycling or remanufacturing, which require more intensive processing. Reuse preserves the original form of materials, conserving both energy and resources. This principle is especially important for infrastructure because viaducts and bridges often have a shorter functional lifespan compared to their technical lifespan. Although these structures may remain technically sound, evolving infrastructure needs, regulatory changes, or design updates can make them obsolete for their original function. However, by repurposing these technically viable components, their utility can be extended in new projects, thereby minimizing waste and reducing the demand for new raw materials. The relevance of reuse is further emphasized by its alignment with the outcomes of the SBIR Circular Viaducts program. Where two of the three winning consortia centered their solutions on reusing components from existing infrastructure. This demonstrates the practical applicability of the reuse principle in achieving circularity within infrastructure projects.

The next step in implementing reuse on a larger scale lies in CPP. Given that approximately 70% of infrastructure projects are publicly funded (TenderNet, 2023), public procurement has a significant role to play in driving circular practices. Ensuring that procurement frameworks incorporate circular principles like reuse is essential for scaling up circularity in infrastructure and supporting the broader transition towards a CE.

Table 2.1: 9R Framework by Kirchherr et al. (2017), adopted to infrastructure (Guo et al., 2024; Potting et al., 2017)

Focus	CE Principles	General Explanation	Infrastructure Strategies
Smart production and use	**R0 Refuse**	Make product redundant by abandoning its function or by offering the same function with a radically different product.	Avoid constructing new infrastructure that is not necessary by optimizing existing facilities or using alternative solutions that achieve the same outcome with less or no construction.
	R1 Rethink	Make product use more intensive (e.g. by sharing product).	Promote shared infrastructure use, to maximize the utilization of existing infrastructure and reduce the need for new construction.
	R2 Reduce	Increase efficiency in product manufacture or use by consuming fewer natural resources and materials.	Design infrastructure projects to use fewer materials through efficient design.
Extending the life of road infrastructure and components	**R3 Reuse**	Reuse by another consumer of discarded product which is still in good condition and fulfills its original function.	Repurpose materials from decommissioned infrastructure in new projects.
	R4 Repair	Repair and maintenance of defective product so it can be used with its original function.	Regular maintenance and repairs of existing infrastructure to prolong its life and ensure it continues to function effectively, reducing the need for new construction.
	R5 Refurbish	Restore an old product and bring it up to date.	Renovate and update old infrastructure to meet current standards and needs without building new structures.
	R6 Remanufacture	Use parts of discarded product in a new product with the same function.	Use parts from old infrastructure in new projects.
	R7 Repurpose	Use a discarded product or its parts in a new product with a different function.	Use of discarded products or components in new products with different functions.
Useful application of materials	**R8 Recycle**	Process materials to obtain the same (high grade) or lower (low grade) quality.	Process construction waste materials, such as concrete and asphalt, to be used as raw materials in new infrastructure projects, maintaining their material quality.
	R9 Recover	Incineration of material with energy recovery.	Recover energy from non-recyclable construction waste through methods like incineration, which can provide energy while reducing the volume of waste sent to landfills.

2.1.2. Circular Public Procurement

In 2015, the European Commission published the Circular Economy Action Plan, noting that public procurement and the purchase of products, services, and works amount to approximately EUR 1800 billion, equivalent to 14% of the European gross domestic product (EU, 2015). Subsequent reports (EU, 2017, 2024) highlight that public procurement contributes to circularity goals primarily through its potential to influence market demand towards more sustainable practices. By prioritizing products and services that adhere to CE principles, public authorities can drive significant market changes. This influence stems from the sheer scale of public procurement, representing a substantial portion of the economy. Incorporating circular principles into procurement practices enables public sector buyers to adopt a more holistic approach to sustainability —from the initial stages of procurement to the end of a product's life— while also achieving potential savings. By embedding CE principles into procurement processes, public authorities not only help achieve environmental goals but also support economic resilience and innovation.

Currently, there are three concepts often used when discussing public procurement based on circular economic principles (Sönnichsen & Clement, 2020):

1. Green Public Procurement (GPP): "A process whereby public authorities seek to procure goods, services, and works with a reduced environmental impact throughout their life cycle when compared to goods, services, and works with the same primary function that would otherwise be procured" (EU, 2024).
2. Sustainable Public Procurement (SPP): "A process whereby organisations meet their needs for goods, services, works, and utilities in a way that achieves value for money on a whole life basis in terms of generating benefits not only for the organisation, but also for society and the economy, whilst minimising damage to the environment" (Programme, 2013).
3. Circular Public Procurement (CPP): "The process by which public authorities purchase works, goods, or services that seek to contribute to closed energy and material loops within supply chains, whilst minimising, and in the best case avoiding, negative environmental impacts and waste creation across their whole life-cycle" (EU, 2017).

All these three types of procurement share the common goal of reducing environmental impacts. In which they increase the complexity of public procurement compared to traditional methods that focus solely on the lowest initial costs. However, each type differs in scope and focus, as illustrated in figure 2.3.

- GPP focuses on reducing environmental impacts by procuring eco-friendly products, achieving moderate waste recovery and landfill impact.
- SPP aims for broader environmental, social, and economic sustainability, with a low landfill ratio and maximum recovery.
- CPP is designed to eliminate waste entirely by maintaining a closed-loop system that achieves zero landfill and 100% material recovery.

Table 2.3: Differences between green, sustainable, and circular procurement (Qazi & Appolloni, 2022)

	Reduced environmental impact	Economic benefits	Open loop	Closed loop	Landfill ratio	Recovery ratio
Green procurement	√	√	√		Moderate	Moderate
Sustainable procurement	√	√	√	√	Low	Maximum
Circular procurement	√	√		√	Zero	100 %

Since these three types of public procurement appear similar, CPP has often been treated as an extension of GPP (Grimbert & Zabala-Iturriagagoitia, 2024). Focusing on purchasing commercialized products rather than fostering innovation. However, CPP requires a broader approach, including system-based thinking and cross-sector engagement. The main challenge is overcoming the fragmented solutions that follow circular principles and instead embracing comprehensive CPP approaches that include product, business model, and ecosystem innovations. Promoting the innovative and disruptive potential of CPP is essential for public procurement to effectively build solutions rooted in the ideals of a CE (Grimbert & Zabala-Iturriagagoitia, 2024).

Although research on the implementation of CPP is limited, it has increased in the last few years. Studies from different regions in the world investigated the conditions that support or hamper CPP implementation (Zijp et al., 2022). However, Leipold et al. (2022) suggest that research has focused on concepts and less on real-world applications and processes. On the other hand literature states that the CE concept has mostly been driven by practitioners and policy makers (Korhonen et al., 2018). Thus, this highlights the need to combine empirical implementation studies with concepts (Lingegård & von Oelreich, 2023). Qazi and Appolloni (2022) add to this by concluding that there is a pressing need for more empirical studies on implementation of CPP. Additionally, product-specific studies are essential to enable governments and practitioners to stay informed about best practices and effectively apply them in their work.

To address this gap, the next section explores interventions from the literature that support the adoption of CPP. In a later stage, these interventions will be integrated into an empirical study using the Q-sort method, helping to bridge the gap between theory and practice.

2.2. Interventions

This section provides an overview of the interventions that can support the adoption of CPP, as well as the limitations that necessitate these interventions. Due to the limited amount of research focused specifically on CPP, this study draws on related fields such as GPP and SPP, using methodologies previously applied by Sönnichsen and Clement (2020) and Alhola et al. (2018). For simplicity, these concepts are collectively referred to as CPP throughout this research.

Currently, there is a lack of specific research directly identifying interventions for CPP. To address this gap, the chapter begins by examining the barriers and challenges discussed in existing literature. From these barriers, interventions are derived—actions, strategies, or measures that, while not always explicitly labeled as such, are aligned with overcoming these challenges. An intervention is defined as “a purposeful and planned action taken by individuals or organizations to address a particular situation, problem, or challenge” (Zhang & Chowdhury, 2024).

The literature review revealed six core categories under which these interventions are grouped: finance, knowledge, leadership and strategy, policy and regulation, organization, and implementation. These categories represent the main challenges that hinder the adoption of circular practices within public procurement processes. While the primary focus of this research is on the infrastructure sector, literature based on other sectors are also considered due to the scarcity of studies specifically dedicated to CPP in infrastructure.

By approaching the literature through this framework, this section aims to compile a foundational list of interventions that will be further enhanced with a empirical document review.

2.2.1. Finance

Financial limitations are a significant barrier to adopting CPP (Filho et al., 2019). Circular products and services are often perceived as more expensive than their traditional counterparts (Blair & Wrigh, 2012; Marchuk, 2020; Preuss, 2009), which complicates the procurement process and decision-making. The overarching goal of public procurement is to obtain goods at the most favorable price/quality ratio, and this is a challenge with circular options. As noted by Lysons and Farrington (2006) and supported by Chari and Chiriseri (2014), the relatively low cost-effectiveness of circular procurement, coupled with budget limitations, presents a crucial obstacle to broader adoption. These economic pressures lead public organizations to shy away from novel circular solutions and opt for proven technologies to avoid financial risk, as highlighted by Coenen et al. (2022).

An underlying cause of these economic barriers is the absence of appropriate legal and regulatory frameworks that would incentivize circular practices, such as tax breaks or subsidies (Perera et al., 2016). Strong regulatory frameworks could provide the necessary financial incentives and create a more predictable environment for both public and private entities, ensuring adherence to sustainability standards and reducing perceived risks. Without these frameworks, sustainable infrastructure projects are often considered too costly or risky, discouraging investment and adoption by the public sector.

Another financial barrier involves the high costs associated with testing, storing, and transporting materials, particularly in the context of reuse (Marchuk, 2020). Even without looking at the financial picture, these activities already create a significant barrier, as they considerably increase the organizational capacity needed to implement reuse practices. From a financial perspective, these costs make it particularly challenging for public organizations to adopt reuse strategies.

Furthermore, financial constraints impact other areas, such as awareness, risk-averse culture, and inadequate training. As indicated by Butler and Keaveney (2014), budgetary decisions often determine the extent to which solutions to these barriers are implemented. The recurring theme of financial limitations will be further examined as other barriers are discussed.

To address these financial barriers, interventions have been identified that could help shift public procurement practices towards more circular approaches:

1. **Establish financial implications:** It is important to establish the financial implications- both positive and negative- of implementing CE principles in public procurement. The existing financial systems that support traditional linear business models may not always provide clear or helpful guidance for circular alternatives. Organizations should develop clear financial assessments that consider both the immediate and long-term financial impacts of circular practices, as suggested by the (BSI, 2017)
2. **Adopting Life-Cycle Costing (LCC):** One specific intervention to enhance the financial decision-making in CPP is the adoption of the Life-Cycle Costing approach. This approach goes beyond considering only direct costs, such as design and realization, by also including future costs related to management, maintenance, and possible demolition. By accounting for the entire lifecycle of a product or service, LCC provides a more comprehensive view of the overall financial impact and helps avoid unforeseen long-term costs (De Giacomo et al., 2019). Shifting focus from the initial investment costs to LCC allows public procurement to better appreciate the long-term value and cost savings that circular practices can offer. Which helps mitigate the perceived high costs and financial risks.
3. **Investing in organizational and operational change:** It is also important to invest in organizational and operational change to support circular practices. Resources should not be limited to specific pilot projects or technologies. Instead, they must be allocated to broader, structural changes within organizations and operations Coenen et al. (2022). This involves altering organizational culture, practices, and resource allocation to prioritize circular approach over traditional ones. As argued by Coenen et al. (2022), making these structural changes is essential to overcoming the financial barriers that hinder circular procurement.

2.2.2. Knowledge

A barrier to the adoption of CPP is the lack of awareness regarding sustainable practices among key stakeholders. According to Butler and Keaveney (2014), this inertia is a critical issue. McMurray et al. (2014) similarly identifies this lack of awareness as a primary barrier to implementing CPP. This includes insufficient efforts to raise awareness about the importance of sustainable development and how sustainable procurement can support this process. Another aspect is that this gap is particularly evident among decision-makers in organizations, including procurement directors and senior managers, whose awareness levels significantly influence the decision to implement CPP and the number of tenders incorporating environmental criteria (Testa et al., 2012). When awareness levels are low, decision-makers often perceive the risks of using unfamiliar tools as outweighing the potential benefits, a conclusion supported by Sönnichsen and Clement (2020).

Closely related to a lack of awareness is the lack of experience with circular practices. Organizations and individuals often lack the necessary experience with circular procurement, which can hinder its

implementation (Cheng et al., 2018). A significant number of public procurement employees are not familiar with basic circular procurement principles such as full-life costing and the evaluation of externalities (Filho et al., 2019). This is further confirmed by Bouwer et al. (2006), where a third of respondents reported struggling with a lack of experience in environmental subjects and in determining environmental criteria. Similar findings by Cheng et al. (2018) and Perera et al. (2016) highlight that there remains a lack of knowledge on integrating social and environmental criteria in tender specifications, which hampers the implementation of CPP practices. Awareness and experience, therefore, are more critical for the successful implementation of CPP than even economic resources, as Sporrong and Bröchner (2009) points out.

Another barrier to effective CPP is the lack of clarity and consistency in CE terminology (Adams, 2021). The methods for implementing CE principles are often vague and uncertain (De Jesus & Mendonça, 2018). Consequently, the term ”CE” has been misunderstood, applied inconsistently, and interpreted differently by governments, companies, and individuals (Chamberlin et al., 2013). This confusion is exacerbated by a lack of understanding of the practices and initiatives that may already align with CE principles or embody CE thinking (ZWS, 2015).

Finally, Adams (2021) identifies the lack of information exchange as a barrier to developing CE business models. There is a significant diffusion of knowledge regarding products and materials across the supply chain, caused by a lack of systems and practices for collecting, sharing, and utilizing CE information (Tura et al., 2019).

To address these knowledge-related barriers, several interventions have been identified that could facilitate the successful implementation of CPPpractices:

1. **Incorporating CE training into professional requirements:** Organizations should incorporate CE training into the professional licensing requirements for purchasers, engineers, and contractors. Such requirements will encourage these professionals to seek knowledge and skills related to circularity, thereby enhancing awareness and understanding of sustainable practices across the board. By formalizing CE training within professional standards, organizations can ensure a baseline level of knowledge and commitment to circular principles across all relevant staff (Cruz Rios et al., 2021).
2. **Training employees on the benefits and practices for CE implementation:** Another intervention is to train employees to understand the benefits, tools, and strategies for applying CE principles in procurement. Skills improvement training can help employees acquire practical knowledge on implementing circular procurement, thereby addressing both the awareness and experience gaps identified as barriers (Qazi & Appolloni, 2022). Regular training programs and workshops can provide procurement professionals with the necessary understanding to incorporate sustainability criteria into tenders and procurement decisions effectively.
3. **Establishing best practices:** Developing a comprehensive set of best practices is important for enabling the successful implementation of circular procurement. According to Qazi and Appolloni (2022), empirical studies based on real-life examples—highlighting both successes and failures—will provide valuable insights to all stakeholders, including governments and practitioners. Documenting and sharing these best practices can facilitate a smoother transition to circular procurement by providing guidance and proven strategies for overcoming common challenges.
4. **Increasing organizational learning capability:** Building a learning-friendly environment within procurement departments can further support the adoption of CPP. This can be achieved by initiating pilot projects that encourage experimentation and collaboration with external actors, including suppliers, to develop innovative circular solutions (Kristensen et al., 2021). By fostering a culture of continuous learning and adaptation, organizations can more effectively integrate CE principles into their procurement practices. These pilot projects provide hands-on experience, allowing staff to develop practical skills and confidence in implementing circular procurement.

2.2.3. Leadership and Strategy

Effective implementation of CPP requires strong leadership and a solid commitment from top management. Research indicates that the stance of top management toward sustainability is a key factor influencing the likelihood of an organization engaging in sustainable procurement practices. For example, Roman (2017) found that the probability of an agency adopting sustainable procurement practices is positively associated with the commitment of its senior management to sustainability goals. However, there is often a lack of top management commitment in practice, which poses a significant barrier to CPP implementation.

Smith et al. (2016) underscores the critical role of top management facilitators in fostering an environment suitable for integrating CPP at political, administrative, cultural, and commercial levels. The research highlights the importance of setting clear political goals, directing funding toward initiatives that facilitate change within designated timelines, and enhancing cross-departmental collaboration and cooperation, even under financial constraints. This level of strategic ambition and support from top management is essential for creating and maintaining continuity, which is important for implementing effective CPP processes (Bloch & Bugge, 2013; Cheng et al., 2018). However, the literature shows that such strategic ambition is often missing, causing disruptions in the continuity and consistency needed to drive CPP initiatives forward.

To address these leadership and strategic barriers, several interventions have been identified that can help guide public sector organizations toward more effective circular procurement practices:

1. **Top-level management support:** The most frequently highlighted factor enabling CPP practices is strong support from an organization's leadership. According to Brammer and Walker (2011), support from top management significantly influences procurement behavior by ensuring that CPP principles are integrated into organizational planning, strategies, and goal-setting. Top-level management must provide a clear mandate for CPP, which includes addressing common barriers such as a lack of experience or a risk-averse culture. As emphasized by Smith et al. (2016), management support should extend to clear political goals, allocation of funds for change, and fostering cross-departmental cooperation and commitment, even under budget constraints. This level of involvement and support from leadership is essential for creating and maintaining continuity in CPP practices.
2. **Clear strategy and commitment to policy:** A clear strategy and strong commitment to policy is of great importance for advancing CPP. According to Leire and Mont (2010), the systematic implementation of CPP practices requires a structured approach that includes developing internal policies incorporating CE elements, setting purchasing criteria, implementing assurance practices, managing supplier relations, and building internal capacity. These steps ensure that circular practices are not just ad-hoc but are embedded systematically within the organization's procurement processes. A clear strategy also ensures that circular procurement goals are articulated and enshrined in concrete strategies and plans, which are crucial for achieving sustained progress in CPP.
3. **Circular integration across procurement phases:** Another important aspect of strategy involves ensuring that circular practices are consistently applied throughout all phases of the procurement cycle. Qazi and Appolloni (2022) outlines the importance of integrating CPP at every stage of the process, from preparation to execution. By embedding circular principles throughout the procurement process, organizations can ensure that sustainability is a core consideration at every step, reducing the likelihood of reverting to traditional, non-circular methods. This approach requires commitment from top-level management to oversee and guide these integrative strategies, ensuring consistency and effectiveness in circular procurement.

2.2.4. Policy and Regulation

While policy and regulation have the potential to act as powerful drivers of change, they are often cited as one of the most significant barriers to the development of a CE (De Jesus & Mendonça, 2018). According to Adams (2021), the absence of robust policy and legislation enabling the transition to the CE presents a major obstacle. Even where policies do exist, they are frequently criticized for being weak, ineffective, or inadequate. The implementation of these policies is often burdened with administrative complexities that hinder their execution, adding another layer of difficulty for organizations seeking to adopt CPP practices (Rizos et al., 2015).

A lack of flexibility in existing laws also poses a barrier to CPP adoption. As highlighted by Bloch and Bugge (2013), current laws are not well-suited for accommodating the reuse of materials. Standardization is essential for assessing used, or secondary, materials, typically forming the basis for certifications that facilitate trade and business transactions. However, the prevailing standards often overemphasize specifications required for virgin materials, imposing disproportionately high requirements on the assessment of used materials' performance capacity. As a result, materials that fail to meet these stringent requirements cannot be certified or sold to potential users. This issue restricts the market for reused materials and inadvertently promotes continued reliance on virgin materials. Zu Castell-Rüdenhausen et al. (2021) emphasize the need for standards specifically designed to facilitate the reuse and purchasing of such materials, which could help overcome these challenges and promote a more sustainable approach to material use in industries.

Furthermore, organizations' ability to adopt CPP practices is hindered by insufficient understanding of specific CPP regulations. There is often a lack of legal expertise required to implement environmental criteria in public procurement processes (Cheng et al., 2018). When it comes to the issue of reuse, Marchuk (2020) notes that the regulatory framework is frequently unclear and overly strict, making it challenging to adopt reuse practices. The slow development of new regulations and a general unfamiliarity with procurement procedures for reused materials add to the complexity and deter organizations from pursuing circular options.

To address these policy and regulatory barriers, interventions have been identified that could provide the direction for support to advance CPP practices:

1. **Direct support:** Direct support involves explicit actions and measures that enforce or facilitate the implementation of circular procurement practices. According to Butler and Keaveney (2014), specific regulations and legislative measures are key drivers of green public procurement (GPP), and similar approaches can be adapted for CPP. Possible measures include establishing sustainability criteria in public procurement processes, mandating that suppliers demonstrate circularity in their products and services, offering tax incentives or grants for circular initiatives, and developing standards and certifications for circular products and services (Loops, 2023). Such direct support can provide a clear, enforceable framework that encourages organizations to adopt CPP practices by reducing uncertainties and administrative burdens associated with compliance.
2. **Indirect support:** Indirect support encompasses softer measures, such as European and national guidelines or recommendations that, while not legally binding, influence stakeholder behavior and expectations toward CPP. These measures help create an enabling environment that encourages circular procurement without imposing strict legal requirements. Hall et al. (2016) argue that indirect support through soft regulation and policy advice is crucial for "greening" procurement. Examples of such support include funding for capability building and awareness programs, facilitating the creation of advocacy platforms, and endorsing contracts that allow the sharing of risks and revenues among stakeholders (Adams et al., 2017). In The Netherlands, for instance, the Rijkswaterstaat has set a target to be fully circular by 2030, which serves as an aspirational goal for stakeholders to align with (Adams, 2021; Ministerie van Infrastructuur en Waterstaat, 2024).

2.2.5. Organization

Organizational capacity is a critical factor in the successful adoption of CPP (Testa et al., 2012). A lack of capacity within organizations, including insufficient resources such as time, money, and promotion policies, is frequently cited as a significant barrier. According to a survey by Bouwer et al. (2006), 35% of public administrations report challenges related to these constraints. This obstacle is increased

by difficulties such as a lack of operational and/or information tools, inadequate training, and a lack of competence in environmental matters. PRIMES (2016) indicates that the requirement of wider knowledge and skills currently exceeds the capacity of procurement departments. As a result, even if there is a desire to implement CPP, the actual execution might be hindered by these gaps in capabilities and resources.

In addition to resource constraints, a risk-averse culture prevalent in many public authorities further complicates the adoption of innovative circular solutions. Cinar et al. (2019) notes that this reluctance to take risks, coupled with a fear of failure, significantly hampers innovation in the public sector. This cultural hesitancy contrasts with the private sector, where innovation is more readily embraced. When attempting to integrate circularity into procurement practices, numerous risks emerge. As a result, public organizations find it challenging to embrace and implement circular innovations. This is due to their limited benefits from risk-taking and minimal consequences for avoiding risks(Bloch & Bugge, 2013). Additionally, Kirchherr et al. (2017) identified a 'hesitant company culture' as a primary cultural hindrance in such settings. Influencing the mindsets of key individuals is essential for overcoming this culture (Adams, 2021).

Smaller public authorities face even greater challenges due to limited resources and less familiarity with the tools required to support CPP. Michelsen and de Boer (2009) and Testa et al. (2012) point out that despite efforts such as pilot projects and financial support, these organizations often struggle to implement CPP effectively. Smaller authorities often do not have specialized staff or full-time managers dedicated to CPP, who would need time and training to develop the necessary knowledge and skills. As a result, small public authorities may struggle to allocate sufficient resources to manage CPP effectively, particularly if procurement responsibilities fall to a part-time worker (Sönnichsen & Clement, 2020).

Finally, the existing procurement practices, which often fail to request or accommodate innovative solutions in tender documents, further hinder the adoption of CPP. This lack of flexibility in procurement processes prevents governments from quickly adapting to new ideas that could enhance environmental and social outcomes in public projects (Coenen et al., 2022; Perera et al., 2016).

To address these organizational challenges and promote the adoption of CPP, several interventions have been identified:

1. **Implementing change management:** A structured change management approach is essential for transitioning to circular practices within public organizations. Change management focuses on aligning organizational culture, strategies, and processes with CE goals. This involves defining the change required, identifying key stakeholders, communicating a clear vision, and assessing the organization's readiness for change (BSI, 2017; Ripanti & Tjahjono, 2019). By implementing a change management system, organizations can ensure that their culture supports a shift towards more sustainable and circular operations. This intervention is crucial for overcoming the internal resistance and operational challenges that often impede the adoption of CPP (BSI, 2017).
2. **Enhancing inter-departmental Coordination:** Inter-departmental coordination is necessary to integrate circular principles across various functions within public organizations. The procurement team alone cannot achieve circularity; it requires collaboration with other departments such as asset management, sustainability, and operations (Qazi & Appolloni, 2022). By fostering better communication and coordination between departments, public organizations can more effectively implement circular procurement practices and overcome the siloed approaches that often hinder progress.
3. **Promoting inter-organizational coordination:** Beyond internal coordination, fostering strategic relationships with external stakeholders is vital for advancing CPP. Intermediaries, such as collaborative platforms or market facilitators, play a key role in aligning procurement processes with CE goals. These intermediaries help bridge the gap between public authorities and the market, facilitating the exchange of knowledge and collaboration needed to implement innovative circular solutions (Rainville, 2021; Vanacore et al., 2023). By promoting inter-organizational coordination, public organizations can build a more adaptable and responsive procurement system that supports the broader adoption of circular practices.

2.2.6. Implementation

A key barrier to implementing CPP is the lack of market mechanisms to support the recovery and reuse of secondary materials. Stakeholders highlighted the need for financial incentives and mechanisms to address market volatility and ensure the availability of high-quality secondary materials for reuse. Additionally, a general lack of understanding about CE principles and the technical challenges of reusing older components further complicate efforts. Concerns around insurance, warranties, and the practicality of using reused materials, especially in structural applications, add to the challenge. Assurance schemes and take-back programs for secondary materials were identified as crucial enablers by contractors and demolition experts to advance circular practices (Adams et al., 2017).

Current procurement approaches are typically characterized by project-based management, where unique, temporary collaborations address specific needs, often relying on custom-made solutions with little standardization. This lack of standardization limits scalability and efficiency across procurement practices, as projects are managed individually with distinct specifications, timelines, and resource allocations. As a result, the ability to scale up innovative ideas essential for improving sustainability and achieving environmental goals is hindered. Without standardized processes, each project requires unique solutions, slowing down the sharing of best practices and reducing the potential for widespread adoption of effective circular strategies. This observation is based on studies related to construction ecosystems, although it is not specific to procurement contexts (Havinga et al., 2023).

To address these barriers and enhance the implementation of CPP, two interventions have been identified:

1. **Pilot projects:** An effective method to acquire new knowledge and skills for CPP is through the implementation of pilot projects. Pilot projects serve as experimental platforms to engage with external actors, including suppliers, to explore innovative approaches to achieving circular solutions (Kristensen et al., 2021). Research by Kristensen et al. (2021) suggests that while the first project is often the most challenging to initiate and complete, subsequent CPP projects become easier to manage as organizations build experience and expertise. The learning curve associated with pilot projects allows staff to gain practical experience, making it easier to adopt CPP practices more broadly. For scaling to be effective, lessons learned from these pilot projects must be mainstreamed across the organization, ensuring that all departments are engaged and aligned with circular procurement goals (Sandberg et al., 2023).
2. **Adopting a product-based approach:** Moving from a project-based to a product-based approach in procurement could significantly improve the scaling of circular practices. Unlike the traditional project-based management that often hampers innovation and scalability, the product-based approach emphasizes standardization, repeatability, and long-term partnerships. This method encourages the development and use of standardized products that meet predefined criteria and quality standards, ensuring consistency across multiple projects and procurement cycles (Havinga et al., 2023). By focusing on standardization, the product-based approach allows for economies of scale, reduces variability in outcomes, and enhances the efficiency of the procurement process, making it easier to implement new technologies and processes that contribute to sustainability goals.

2.2.7. Summary of Interventions

In conclusion, the adoption of CPP faces significant challenges across the six key categories: finance, knowledge, leadership and strategy, policy and regulation, organization, and implementation. An overview of the barriers found in literature, along with the sector they were found in, can be found in appendix B. In response to these challenges, this section has explored various interventions aimed at overcoming them and promoting the up-scaling of CPP practices.

These interventions, of which an overview can be found in table 2.4, provide a theoretical foundation for addressing the challenges of scaling circular procurement. They also lay the groundwork for further empirical research, which will be used expand on this list of interventions and to gather and analyze the perspectives of practitioners on the most critical interventions.

Table 2.4: Collected interventions through theoretical approach

No.	Category	Intervention description	Extract from source	Source	Source Description
1	Finance	Establish financial implications	”Organizations should establish the financial implications (positive or negative) of implementing the principles of the CE. Existing legal and financial systems that support traditional forms of business might not necessarily be helpful or clear.”	(BSI, 2017)	Research on implementing the principles of the circular economy
2	Finance	Considering Life-Cycle Costing (LCC)	”LCC enables public authorities to achieve cost savings and efficiency gains, leading to a ‘win-win’ situation: a greener product or service can also turn out to be cheaper if the overall cost across the whole life cycle is considered”	(De Giacomo et al., 2019)	Paper on Green Public Procurement and Life Cycle Costing, not sector specific
3	Finance	Invest in organizational and operational change	”When used for circularity, available resources are often allocated to specific pilot projects and technologies, while for making steps in circularity, resources need to be allocated to structural organizational and operational change.”	(Coenen et al., 2022)	Article on transition barriers to a circular infrastructure sector
4	Knowledge	Incorporate CE training into the professional license requirements	”Organizations should incorporate CE training into the requirements of purchasers, engineers, and contractors. Such requirements will encourage seeking knowledge and skills about circularity.”	(Cruz Rios et al., 2021)	Paper on barriers and enablers towards CE in construction, in the US
5	Knowledge	Train employees to learn benefits and practices for CE implementation	”Skills improvement training of employees can help to learn benefits, tools, and strategies to apply a CE.”	(Qazi & Appolloni, 2022)	Review article on barriers and enablers towards CP
6	Knowledge	Establish Best Practices	”Empirical studies should be conducted based on real-life examples. It will help all stakeholders, especially government and practitioners, to follow best practices. For example, real success and failure stories in implementing circular procurement.”	(Qazi & Appolloni, 2022)	Review article on barriers and enablers towards CPP

No.	Category	Intervention description	Extract from source	Source	Source Description
7	Knowledge	Increase organizational learning capability	”Providing a learning environment supports the procurement departments in acquiring new knowledge and skills for CPP, which involves pilot projects used to experiment with external actors and the involvement of suppliers in new innovative ways of achieving circular solutions.”	(Kristensen et al., 2021)	Article on CPP practices in the public sector in Denmark
8	Leadership and Strategy	Top level management support	”The most frequently highlighted stimulant of SP practices were support for SP among an organisation’s leadership, and the implementation of concrete strategies and plans within which SP goals were articulated and enshrined.”	(Brammer and Walker, 2011)	Article on sustainable procurement in the public sector
9	Leadership and Strategy	Clear strategy	”A clear strategy and commitment to policy is important towards CPP.”	(Leire and Mont, 2010)	Paper on Socially Responsible Purchasing in the public sector
10	Leadership and Strategy	Circular integration across Procurement Phases	”..the sourcing strategy and procurement process should be redefined by incorporating circularity at all stages”	(Qazi & Appolloni, 2022)	Review article on barriers and enablers towards CPP
11	Policy and Regulation	Direct support	”The results of the questionnaires were similar to those identified in the literature review with regulations and legislation set by the EU coming out on top as the key driver of GPP.”	(Butler and Keaveney, 2014)	Paper on barriers and drivers of GPP in the construction industry
12	Policy and Regulation	Indirect support	”The analysis shows that indirect support through European and national soft regulation and policy advice is imperative for “greening” procurement.”	(Hall et al., 2015)	Paper on the challenges of green procurement at the local level

No.	Category	Intervention description	Extract from source	Source	Source Description
13	Organization	Implement change management	”Agree and implement a change management system to enable the organization to implement and sustain the planned change and ensure the prevailing culture is supportive of a move towards a more circular and sustainable mode of operation.”	(BSI, 2017)	Research on implementing the principles of the circular economy
14	Organization	Inter-departmental coordination	”Inter-departmental coordination and commitment can enhance the use of recycled, remanufactured, and repaired material. The procurement team alone cannot apply circularity.”	(Qazi & Appolloni, 2022)	Review article on barriers and enablers towards CP
15	Organization	Inter-organizational coordination	”Collaboration provided strategic bridges enabling the exchange of knowledge between organizations, towards solving problems that no party could address unilaterally.”	(Rainville, 2021)	Article on stimulating CE through PP
16	Implementation	Pilot projects	”The first project was the hardest to initiate and complete. However, following these initial experiences and learning, the municipalities can more easily engage in new CPP projects. Using pilot projects to gain experiences with CPP can drive the further uptake of CPP, as the staff involved gain new knowledge and learning through their experiences with CPP.”	(Kristensen et al., 2021)	Article on CPP practices in the public sector in Denmark
17	Implementation	Product-based approach	”Collaboration in the construction industry is through the traditional project-based management, which hampers innovation scalability, change and growth of the sector... there is a positive connection between a construction ecosystem implementing a product-based approach and the extent of partner alignment being performed by the lead firms as well as a stronger iterative use of orchestration mechanisms to achieve partner alignment.”	(Havinga et al., 2023)	Article on the transition toward circular construction ecosystems. Not specific to procurement

2.3. Institutional Logics

Institutional logics are defined as ”the socially constructed, historical patterns of material practices, assumptions, values, beliefs, and rules by which individuals produce and reproduce their material subsistence, organize time and space, and provide meaning to their social reality” (Friedland, 1991). Institutional logics guide both individual behaviors and organizational strategies by shaping norms and rules within specific contexts. They are crucial for analyzing how different belief systems and organizational practices influence decision-making processes within organizations in the infrastructure sector (Thornton & Ocasio, 1999).

In this research, institutional logics provide a framework to understand the perspectives of key stakeholders on the interventions needed to upscale the procurement of circular viaducts and bridges. This relevance becomes apparent after the Q-sort, when stakeholder perspectives will be extracted and connected to institutional logics, offering insights into how these belief systems influence their views on interventions.

2.3.1. Institutional Logics in Organizational Contexts

Within organizational theory, institutional logics explain how organizations manage multiple belief systems and how these systems coexist, conflict, and interact within their structures (Besharov & Smith, 2014). Organizations, especially in complex environments such as infrastructure, often navigate institutional pluralism, balancing and integrating different logics (Jay, 2013).

Thornton et al. (2012) explain that institutional logics influence how organizations shape their strategies, policies, and practices. This theoretical perspective is particularly relevant for understanding the infrastructure sector’s response to paradigms like the CE. The sector frequently negotiates among different logics that can be contradictory, such as sustainability goals versus cost-efficiency or long-term asset management versus project-oriented approaches (Greenwood et al., 2011).

2.3.2. Institutional Logics in Infrastructure

Coenen et al. (2024) identified four dominant institutional logics that shape how infrastructure is planned, managed, and executed. Understanding these logics are important for understanding the perspectives on the needed interventions for up-scaling the procurement of circular viaducts and bridges:

1. **State Logic:** Characterized by an emphasis on procedural adherence, transparency, and accountability, state logic reflects the bureaucratic nature of public sector organizations. This logic is dominant in public infrastructure agencies, where legitimacy, control, and compliance with regulations are prioritized. In circular procurement, state logic often results in rigid decision-making processes that prioritize regulatory compliance over innovation.
2. **Asset Management Logic:** Focused on the long-term preservation and maintenance of infrastructure assets, this logic is risk-averse and prioritizes efficient resource use to ensure asset reliability and continuity. In the context of circular procurement, asset management logic tends to favor conventional approaches that align with existing maintenance and resource allocation frameworks, limiting the uptake of innovative circular solutions.
3. **Project Logic:** Defined by short-term, task-oriented decision-making, project logic emphasizes project efficiency, feasibility, and scope delivery within defined budgets and timelines. This logic is prevalent in temporary project organizations and private sector contractors involved in infrastructure projects. In relation to circular procurement, project logic can drive innovation in specific projects but may lack the systemic perspective needed for broader adoption and scaling.
4. **Sustainability Logic:** Driven by values of innovation, environmental stewardship, and long-term social responsibility, sustainability logic is often found within strategic and knowledge departments of organizations. While it advocates for sustainable practices, including CE principles, its influence is typically overshadowed by the more dominant state and asset management logics. This limits its impact unless there is strong alignment and support from higher organizational levels.

In his research, Coenen briefly mentions two additional logics that, while not identified as part of the four dominant logics, still play a role in infrastructure:

5. **Market Logic:** Market logic focuses on efficiency, profitability, and competition. In the context of circular procurement, this logic drives stakeholders—especially private sector parties like contractors and suppliers—towards economically viable solutions. While market logic can encourage the adoption of circular practices when they align with financial incentives, it can also present a barrier if circular solutions are seen as increasing costs or risks without clear economic benefit.
6. **Community Logic:** Community logic emphasizes collaboration, shared values, and trust among stakeholders. This logic is often visible in experimental or pilot projects where public and private actors work together on circular initiatives. Although it promotes innovation through cooperation, community logic typically exists outside formal organizational frameworks, which limits its potential for wider institutionalization and the broader scaling of circular practices.

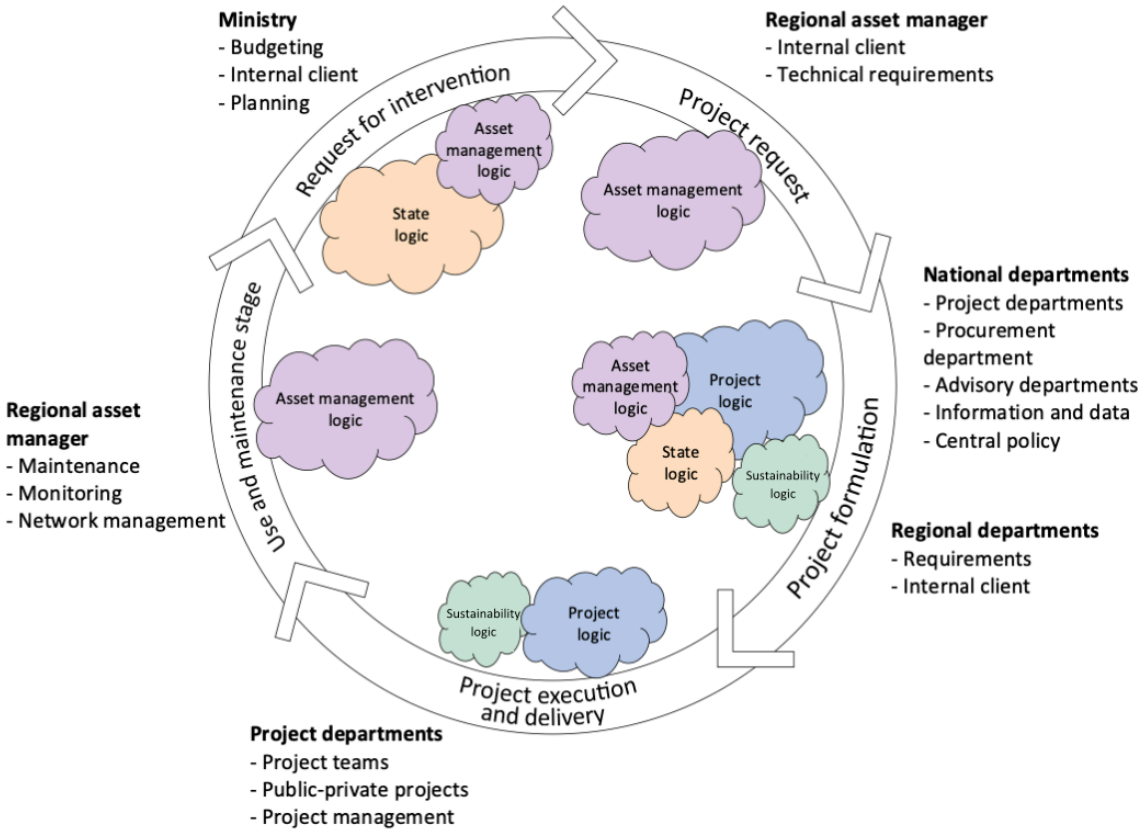

Figure 2.1: Asset lifecycle process coupled to dominant logics per phase (Coenen, 2024)

The integration of CE principles into the infrastructure sector is particularly challenging due to the dominant institutional logics at play. The rigid nature of state and asset management logics, which prioritize regulatory compliance and the long-term preservation of infrastructure assets, often clashes with the flexibility needed to implement CE practices (Coenen et al., 2024). These logics, therefore, serve as key barriers to adopting innovative circular solutions, and understanding them helps explain the various perspectives on interventions required to scale up circular procurement for viaducts and bridges. Figure 2.1 illustrates the dominant logics present in each phase of the infrastructure asset lifecycle, with the project formulation phase—where procurement decisions are made—being most influenced by asset management, project, state, and sustainability logics (Coenen, 2024).

2.3.3. Interpreting Perspectives through Institutional Logics

Interpreting stakeholder perspectives on interventions through institutional logics can offer insights but requires a nuanced approach. Institutional logics provide a broad framework, shaping the norms, values, and priorities that inform decision-making within organizations. In contrast, interventions represent specific, actionable methods for implementing new practices, such as circular procurement. Therefore, this comparison does not attempt a direct mapping of interventions to institutional logics. Instead, it aims to interpret how the foundational beliefs within these logics shape or constrain stakeholder perspectives towards types of interventions.

This distinction between institutional logics as overarching frameworks and interventions as concrete actions is important. As it clarifies that while logics guide preferences, they do not dictate specific choices. In this context, Q methodology is used as a tool to interpret how perspectives might align with or differ from established institutional logics, without suggesting that these logics directly control practical actions.

The relevance of this approach is supported by previous studies by Day (2008) and Leong and Lejano (2016), which connects subjective perspectives with institutional frameworks through the use of Q-methodology. These studies show that Q-methodology can effectively capture the "logic" or reasoning frameworks that individuals use. For instance, Day (2008)'s study illustrates how Q-methodology can reveal alignments between stakeholder perspectives and broader policy frameworks, such as the Advocacy Coalition Framework. This suggests that Q-methodology can meaningfully relate subjective viewpoints to established institutional structures, although Day's focus remains on higher-level policy perspectives rather than specific interventions. Thus, while his study aligns perspectives with overarching frameworks, it does not extend this alignment to concrete, actionable interventions.

Similarly, Leong and Lejano (2016) examine how traditional governance logics continue to exist alongside reformist ideas within China's Yellow River IWRM reforms. Their work describes a "thick narrative" where long-standing governance beliefs intersect with new logics, showing that Q-methodology can capture complex, layered stories within institutional contexts. This mix of old and new logics is relevant to my approach, as it demonstrates how stakeholder perspectives can reflect deeply embedded institutional logics. However, Leong and Lejano's study also remains at the level of governance narratives and does not focus on specific intervention strategies.

Together, these studies affirm the suitability of Q-methodology for examining how individual perspectives relate to institutional frameworks. However, neither study directly connects institutional logics to specific, operational interventions. By applying institutional logics as interpretive frameworks, this study aims to uncover the broader institutional influences behind stakeholders' practical choices and preferences. To frame this interpretive process, two distinctions are important:

1. Institutional logics are broad, socially constructed frameworks that set foundational norms, values, and assumptions within organizations, providing a structural basis for decision-making. Interventions, however, are specific, operational actions or strategies that stakeholders might adopt within the circular procurement process. This study uses institutional logics as an interpretive framework to contextualize stakeholder perspectives on interventions. Revealing how these perspectives may align with, or challenge these logics, without being directly dictated by them.
2. Stakeholder perspectives are influenced by a wide range of factors, including organizational context, roles, priorities, and practical realities. While institutional logics provide a valuable lens for interpreting these perspectives, they represent just one framework among many that shape stakeholder viewpoints.

2.4. Conclusion

This chapter provided the theoretical basis for understanding key concepts relevant to the thesis. The concept of the CE was explored, with attention to the 9R framework, which emphasizes reducing waste and optimizing resource use. The discussion then shifted to the application of CE principles in the infrastructure sector, where unique challenges like the long life cycle of infrastructure projects complicate circular efforts. Finally, the concept of CPP was examined, illustrating how public procurement can drive the adoption of circular practices by influencing market demand. While CPP holds potential for significant impact, it remains underexplored, particularly in infrastructure, where complexities make its implementation difficult.

The chapter also reviewed a range of interventions aimed at overcoming the key barriers to scaling CPP. These barriers include financial constraints, lack of knowledge, gaps in leadership and strategy, and limitations in organizational capacity and policy frameworks. The interventions discussed in the literature, such as life-cycle costing, training programs, leadership commitment, and regulatory reforms, offer actionable strategies to support the adoption of circular practices. These interventions form the foundation for the empirical part of the study.

The concept of institutional logics was introduced to explain how different belief systems and organizational practices influence decision-making in the infrastructure sector. The dominant logics—state, asset management, project, and sustainability—shape how stakeholders approach circular procurement, sometimes resulting in conflicting priorities. Understanding these logics is an important step for analyzing the diverse perspectives of stakeholders and identifying where alignment or conflict may arise in implementing circular practices.

By laying this theoretical groundwork, this chapter prepares for the empirical research, which will examine stakeholder perspectives on scaling CPP in infrastructure. The interventions identified in the literature review and from empirical document analysis will form the basis for the Q-set, capturing a balanced range of theoretically and practically relevant statements. This dual approach ensures that the empirical study not only reflects established academic insights but also addresses real-world challenges observed in practice. Through the Q-sort, this research will assess stakeholder views on these interventions, identifying both alignment and areas of conflict.

3

Methodology

This chapter outlines the methodology used to explore stakeholder perspectives on interventions needed to upscale the procurement of circular viaducts and bridges. The methodology follows the process of Q-methodology as described by Donner et al. (2001) and Van Exel and De Graaf (2005), see figure 3.1.

Section 3.1 explains the development of the concourse. Section 3.2 details the process of refining this concourse into a subset of statements known as the ”Q-set”. Section 3.3 outlines the selection of a purposive sample of participants, referred to as the ”P-set”. Section 3.4 then describes the procedure for the ”Q-sort” process, where participants rank the Q-set statements based on perceived effectiveness. Section 3.5 discusses the approach to Q-sort analysis, detailing how the Q-sort data is used to identify patterns, extract factors. Finally, section 3.6 describes the steps taken for interpreting the distinct perspectives among the participants.

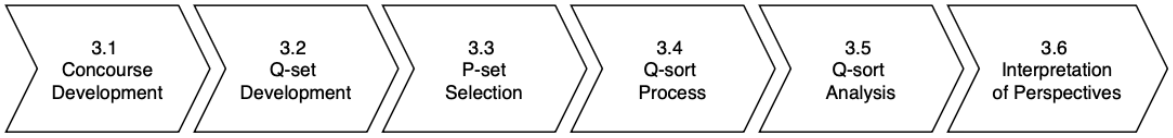

Figure 3.1: Flowchart outlining the steps of the methodology

3.1. Concourse Development

The concourse is a technical concept often used in Q-methodology, referring to the complete set of possible statements that respondents can make about the subject at hand (Van Exel & De Graaf, 2005). It can be developed from various sources such as interviews, newspapers, and literature (Brown, 1993). For this research, the concourse will be developed using both literature and empirical research, ensuring a comprehensive set of interventions. A flowchart of this process is presented in Figure 3.2.

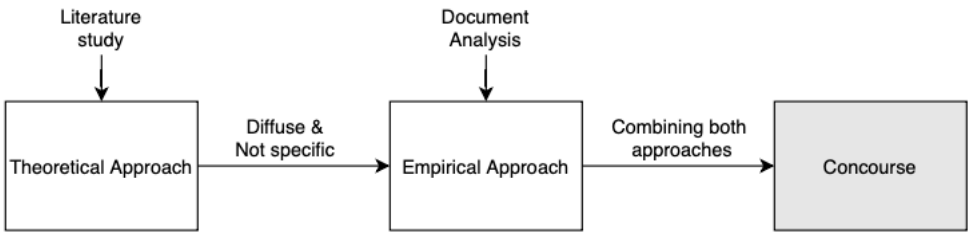

Figure 3.2: Flowchart of the concourse development

The first step involves gathering interventions identified through a literature review. However, literature on up-scaling circular procurement is often diffuse and not specifically tailored to infrastructure, particularly circular viaducts and bridges. Relying solely on literature would therefore not provide a complete picture of all possible interventions.

To address this limitation, the initial list of interventions from the literature will be expanded with interventions identified in empirical documents. As the Dutch infrastructure sector has seen significant developments and research on circular viaducts and bridges in the past years, this will help create additions to the list of interventions. Through integrating insights from both academic research and practical applications, this process aims to capture a comprehensive view of the interventions needed to upscale the procurement of circular viaducts and bridges.

The following subsections provide more details on the processes of identifying the theoretical and empirical interventions and later combining them.

3.1.1. Theoretical Approach

Firstly, in section 2.2 interventions were gathered through a theoretical approach, forming the foundation of the concourse. This approach consisted of a literature study on interventions for circular public procurement. For each intervention, information was collected as shown in table 3.1.

Table 3.1: Showcasing how interventions are collected

Category	Intervention Description	Extract from source	Source and Source description
Categorizing the intervention	*A short description of the intervention*	*An excerpt from the source which defines or describes the intervention*	*The reference to the source along with a brief description of its content and context.*

3.1.2. Empirical Approach

The next step involves gathering interventions through an empirical document analysis. Since the literature is mostly not specific to infrastructure and does not address viaducts and bridges, this approach aims to gather more context-specific interventions. Documents used include action plans, guidelines, and strategy visions. The interventions are categorized into the same six categories identified during the literature study. For each intervention, information will be collected as shown in Table 3.1.

3.1.3. Combining Approaches

To create an overview, the final step in developing the concourse is combing the two lists of interventions gathered through both the theoretical and empirical approaches. For each intervention, the information will be structured as shown in table 3.2.

Table 3.2: Showcasing how interventions, collected through both approaches, are combined

Category	Intervention Description	Extract from source	Identified Through
Categorizing the intervention	*A short description of the intervention*	*An excerpt from the source which defines or describes the intervention*	*Identified through theoretical approach or empirical approach*

3.2. Q-set Development

The next step is selecting a subset of interventions from the concourse to present to the participants, known as the Q-set (Van Exel & De Graaf, 2005). The selection of interventions from the concourse is crucial, but remains ”more an art than a science” (Brown, 1993). The researcher aims to create a representative selection of the concourse, which can be achieved through further examination of the statements or by imposing a theoretical structure (Van Exel & De Graaf, 2005). According to Webler et al. (2009), it is important to maintain a smaller P-set than Q-set, with an ideal ratio between 3:1 and 2:1. This ensures that the selected Q-set is broad enough to capture diverse perspectives while remaining manageable for analysis.

In this research the interventions will be further examined and narrowed down into a Q-set through two expert interviews. These expert interviews have several goals:

- Verify if interventions are correctly categorized
- Assess if each intervention is clearly described and relevant to upscaling the procurement of circular viaducts and bridges.
- Identify interventions with overlapping descriptions or objectives and suggest combining them
- Suggesting of any missing interventions that could be relevant based on experts’ input
- Select interventions that comprehensively represent the concourse.

The feedback gotten from the expert sessions will be collected and organized as shown in table 3.3.

Table 3.3: Showcasing how the feedback from the expert interviews will be collected

Category	Intervention Description	Extract from source	Identified through	Feedback	Result of Feedback
Categorizing the intervention	*A short description of the intervention*	*An excerpt from the source defining the intervention*	*Identified through theoretical approach or empirical approach*	*Feedback from the experts*	*Outcome based on expert feedback (e.g., included in Q-set, combined with another intervention, deemed irrelevant, modified, etc.)*

3.3. P-set Selection

In Q-methodology, the P-set refers to the sample of participants who will sort the Q-set statements. Unlike traditional survey methods, Q-methodology does not require a large sample size because its goal is to explore the range of viewpoints rather than their frequency in the population (Stenner et al., 2008). The ideal number of participants for a Q-methodology study typically ranges from 12 to 36 (Webler et al., 2009).

As discussed by Webler et al. (2009), “...all that is required are enough subjects to establish the existence of a factor for purposes of comparing one factor with another [...] P sets, as in the case of Q samples, provide breadth and comprehensiveness so as to maximize confidence that the major factors at issue have been manifested using a particular set of persons and a particular set of Q statements.” Typically, the P-set is smaller than the Q-set (Van Exel & De Graaf, 2005). The P-set is not random; it is a structured sample of respondents who are theoretically relevant to the problem under consideration. These are individuals expected to have clear and distinct viewpoints regarding the problem, thereby defining a factor (Brown, 1993). The number of persons associated with a factor is less important than who they are, as the prevalence in the total population may be much higher (Brown, 1993).

In this research, the P-set will include at least 12 participants representing three key stakeholder groups: public contracting authorities, market parties, and knowledge institutions, as outlined in Table 3.4. The public contracting authorities group consists of participants from Rijkswaterstaat, provincial, and municipal levels, allowing the study to capture perspectives on public procurement across different

governmental scales. The market parties group consists of representatives from the three consortia that were awarded contracts under the SBIR Circular Viaducts and Bridges program. This selection ensures that the participants have practical experience with procuring circular viaducts and bridges. Knowledge institutions form the third group, representing a neutral stakeholder perspective; however, it is needed that participants in this group also have experience with circular procurement to provide informed viewpoints.

Table 3.4: P-set distribution

Stakeholder		**Amount**
Public contracting authority	*RWS*	*2*
	Provinces	*2*
	Municipalities	*2*
Market	*Combinatie Liggers 2.0*	*1*
	Closing the loop	*1*
	ViCi	*1*
Knowledge institutions	*IB Westenberg*	*1*
	Brug campus	*1*
	TNO	*1*
Total		**12**

3.4. Q-sort Process

The Q-sort process is the central component of Q-methodology, involving participants ranking the Q-set, based on specific criteria. Typically ranging from ”most disagree” to ”most agree” (Van Exel & De Graaf, 2005). This process reveals the subjective viewpoints of the participants. For this study, the Q-sort will be conducted physically to ensure better engagement and allow for immediate clarification of any questions (Lundberg et al., 2020).

The Q-sort process is generally as follows (Brown, 1993). The Q-set will be presented to participants as a pack of randomly numbered cards, each containing one interventions. Participants will be instructed to rank the interventions according to their personal viewpoints, following a specific condition of instruction. They will be asked to sort the interventions on the provided score sheet that has a quasi-normal distribution. The distribution’s shape depends on the topic’s controversiality (Webler et al., 2009). If participants’ involvement or knowledge is expected to be low, the distribution will be steeper, allowing for more ambiguity in the middle. If participants have strong, well-articulated opinions, the distribution will be flatter, providing more space for strong agreement or disagreement. In this research, a flatter distribution with seven columns was selected, see figure 3.3. This distribution was chosen because, while participants were expected to have well-formed opinions on the topic, prioritizing the interventions might still be challenging. The selected distribution offers a balance: it allows participants to strongly emphasize certain interventions as highly important or unimportant (columns -3, -2, +2, and +3, which accounts for 40% of the statements) while also providing sufficient space to rank the majority of interventions as neutral or moderately important (columns -1, 0, and +1, which hold 60% of the statements).

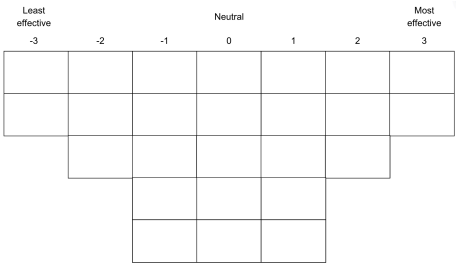

Figure 3.3: Score sheet, with a flatter distribution, used for the Q-sort

After the Q-sort, participants will be asked to discuss their sorting decisions, providing insights into their perspectives. The interview transcript, included in Appendix F, provides a guide. Ensuring consistency and reliability in the Q-sort process, with standardized instructions and questions for uniformity. During the post-sort interview, participants will be asked several questions to capture the nuances in their viewpoints and provide an understanding of their sorting decisions. These questions include:

- Can you explain why you placed certain interventions in the ”least effective, ”neutral”, and ”most effective” category?
- Were there any interventions you found unclear or difficult to rank? If so, why?
- Do you think any important interventions were missing from the Q-set?

These questions aim to capture the nuances in participants' viewpoints and provide an understanding of their sorting decisions, enhancing the study's insights into the perceived effectiveness of various interventions.

3.5. Q-sort Analysis

The Q-sorts performed by the respondents serve as the data for analysis, representing their individual perspectives on intervention for procuring circular bridges and viaducts. The goal of the analysis is to identify shared viewpoints among different groups of interviewees. For instance, if a group of individuals shares similar opinions on key criteria, their Q-sorts will show a high correlation. Conversely, their Q-sorts will show lower correlations with those of individuals outside their group, highlighting distinct perspectives. In this research, KADE is used, which is a desktop application for the analysis of Q-methodology data (Banasick, 2019).

3.5.1. Correlation between Q-sorts

The data analysis will follow a structured approach to uncover and interpret the various perspectives held by respondents. The first step is determining the correlation between Q-sorts, which is calculated using the scores that respondents assign to the different statements. The correlation measures the degree of similarity between the perspectives of different respondents. This correlation is calculated using the formula:

$$r = 1 - \frac{\sum D^2}{\sum S_A^2 + \sum S_B^2} \tag{3.1}$$

Where:

- r is the correlation between Q-sort A and Q-sort B
- D is the difference between the statement scores of A and B
- S is the score given to a statement by the respondent

As the size of the Q-sample increases, the likelihood of two Q-sorts being completely similar or completely opposite decreases. For each Q-sort, the correlation with all other Q-sorts is calculated, resulting in a correlation matrix. This matrix indicates the degree of similarity or dissimilarity in perspectives between different Q-sorts.

3.5.2. Factor Extraction

Factor extraction is an important step in Q-methodology, used to statistically group similar perspectives to identify common viewpoints among respondents. Each factor represents the average perspective of a group of respondents who sorted the interventions similarly. After establishing the correlation matrix, the factor extraction process starts.

Factors can be extracted using either centroid analysis or principal components analysis. While the detailed theory and methods behind these analyses fall outside the scope of this research, it is important to note that the choice of method generally does not significantly affect the final results. The centroid method is the most commonly used in Q-methodology and was the preferred method of its founder,

William Stephenson. It is also endorsed by scholars such as Brown (1993) and McKeown and Thomas (1988). For these reasons, this research employs the centroid method for factor extraction.

The factor extraction process involves several steps to ensure the most accurate and meaningful grouping of perspectives. The KADE application, a free tool specifically designed for Q-methodology, is used for conducting the factor analysis in this study (Banasick, 2019). This application allows for the extraction of one to eight factors (or groupings of perspectives). Determining the optimal number of factors to extract requires careful evaluation against several criteria:

1. **Significant Q-Sorts:** Each acceptable factor must have at least two Q-sorts significantly loaded onto it. A Q-sort is considered significantly loaded onto a factor at the $p \leq 0.05$ level if its factor loading exceeds $1.96 \times SE$, where SE (standard error) is calculated as:

$$SE = \frac{1}{\sqrt{N}} \tag{3.2}$$

   Where:

   - SE is the standard error
   - N is the number of items in the Q-sample

   The statistical significance of the loadings is calculated using the standard error (Brown, 1993):

   - Factor loadings exceeding **±2.58*(SE)** are significant at the **0.01 level**.
   - Factor loadings exceeding **±1.96*(SE)** are significant at the **0.05 level**.

   For a factor to be accepted, it must meet two criteria (Brown, 1993):

   (a) The factor must have at least two significant loadings.

   (b) The factor must meet Humphrey's rule, which states that a factor is significant if the cross-product of its two highest loadings exceeds twice the standard error.
2. **Explained Variance:** The cumulative percentage of explained variance for the extracted factors should be greater than 50%. This ensures that the selected factors account for a substantial portion of the variation in the data.
3. **Humphrey's Rule:** As stated earlier, a factor is considered significant if the cross-product of its two highest loadings exceeds twice the standard error. This makes sure that each factor is robust and reliable.
4. **Simplicity:** Fewer factors are preferable because they make it easier to understand the viewpoints presented. However, oversimplification should be avoided, as it could result in the loss of valuable information about people's differences in opinions.
5. **Clarity:** The best solution is one in which each respondent loads highly on only one factor. The researcher should aim to minimize the number of non-loaders (respondents who do not load significantly on any factor) and confounders (those who load on multiple factors). The existence of confounders may indicate individuals with hybrid views, combining elements from multiple perspectives.
6. **Distinctiveness:** Factors should ideally exhibit low correlations with each other, indicating truly distinct viewpoints. While high correlations between factors are not necessarily problematic, the points where they differ should provide critical insights into the nuances between the perspectives.
7. **Stability:** Throughout different rotations and extractions, the consistency of respondent clustering on factors suggests stable perspectives. These stable clusters should be preserved in the final factor solution to maintain the robustness of the findings.

Applying these seven criteria allows the selection of the most appropriate number of factors. Making sure that the extracted factors provide a good representation of the various perspectives in the data. By balancing simplicity, clarity, distinctiveness, and stability, the final factor solution aims to present a meaningful and interpretable understanding of the viewpoints held by the participants.

3.5.3. Perspective Loadings

The final step is determining the amount of Q-sorts that load significantly on the factors. The significance of these loadings is calculated using the standard error formula 3.2, ensuring that only statistically meaningful factors are extracted and analyzed.

3.6. Interpretation of Perspectives

The interpretation of perspectives combines quantitative and qualitative analyses to provide a complete view of the data. Quantitatively, Q-sort rankings are used to calculate mean Z-scores, identifying distinguishing and consensus statements that highlight unique and shared priorities. Qualitatively, transcribed interviews are analyzed using Atlas.ti, where quotes are coded by intervention and linked to their Q-sort scores. Subsequent co-occurrence analysis identifies patterns and relationships between interventions and rankings, offering insights into participants' reasoning.

The following subsections outline the steps taken to interpret the perspectives.

1. Mean Z scores

Mean Z scores are calculated for each intervention to reflect the collective preferences of participants. These scores, ranging from -3 to +3, indicate how strongly participants agree or disagree with the interventions, providing an overview of perceived effectiveness. Interventions with high positive scores are prioritized as effective, while those with negative scores are considered less impactful.

2. Perspective Interpretation

Distinct perspectives emerge from the Q-sort factor analysis, each characterized by unique patterns of preferences. To interpret these perspectives, distinguishing statements—interventions ranked significantly higher or lower by one perspective compared to others—are analyzed. These statements are supported by quotes from the post-Q-sort interviews and highlight the priorities and focus areas of each perspective.

3. The Non-Loader

Participants whose Q-sorts do not align strongly with any single perspective are considered non-loaders. Their unique viewpoints are analyzed separately to ensure that valuable insights are not overlooked, even if they do not fit neatly into a specific perspective.

4. Consensus Statements

Consensus statements are interventions ranked similarly across all perspectives, reflecting shared agreement among participants. These statements provide insights into common ground, which can serve as a foundation for collaborative strategies.

5. Comparing Perspectives

The perspectives are compared by examining their rankings across intervention categories. This comparative analysis identifies areas of agreement and divergence, helping to develop strategies that address diverse priorities.

6. Missing interventions

During the post-Q-sort interview, participants were also asked if there were any interventions they felt were absent from the Q-set. These missing interventions provide additional context and may highlight areas that require further exploration or action.

7. Experience and Function Group

Finally, participants' professional roles and years of experience are analyzed to understand how these factors influence their priorities.

4

Results

This chapter applies the methodology described in Chapter 3, see figure 4.1. Section 4.1 presents the concourse development results. Section 4.2 outlines the refinement of these statements into a Q-set through expert validation. Section 4.3 finalizes the selection of the P-set, and Section 4.4 details the in-person Q-sort. Section 4.5 covers the Q-sort analysis process in order to identify the perspectives among participants. Due to the depth of analysis required, the interpretation of these identified perspectives is provided separately in Chapter 5.

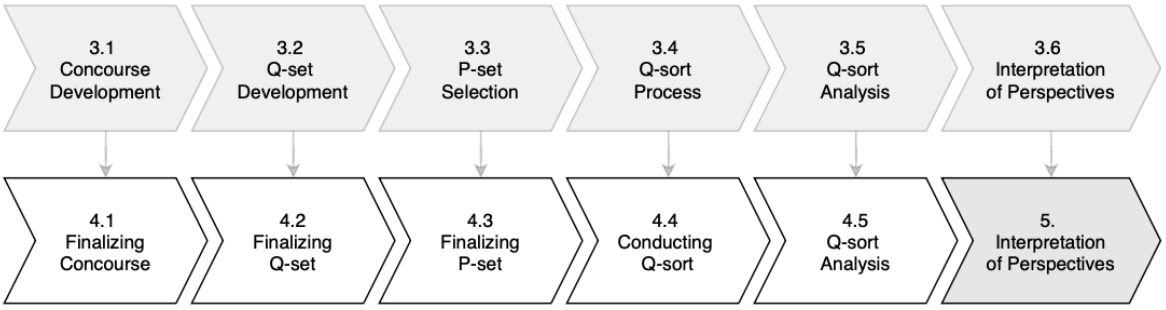

Figure 4.1: Flowchart outlining the steps of the results

4.1. Finalizing Concourse

The concourse development resulted in a comprehensive collection of interventions from both theoretical and empirical sources. A total of 17 interventions were identified through the theoretical approach, which are presented in table 2.4.

Additionally, 31 empirical interventions were gathered from relevant documents, adding practical insights to the theoretical foundation. Examples of the documents used include: Group (2024) Market Vision and Procurement Strategy for Circular Viaducts and Bridges; CB'23 et al. (2021) Guideline Circular Procurement; and group (2023) Action Plan for Climate-Neutral and Circular Working. The full list of empirical interventions can be found in Appendix C. The combined list of interventions can be found in Appendix D.

4.2. Finalizing Q-set

The broad set of interventions was refined into a manageable Q-set through two expert interviews. The two experts selected for this process brought different perspectives to ensure a well-rounded validation. The first expert was a strategic advisor within Rijkswaterstaat, specifically involved in the "Transitie naar Klimaatneutraal en Circulair Werken in 2030" initiative. This expert provided insights

from a governmental and process-driven perspective on the challenges of up-scaling the procurement of circular viaducts and bridges. The second expert was a circularity and sustainability consultant at Witteveen+Bos, offering a more hands-on view on the practical aspects of circularity in infrastructure projects.

Their combined feedback led to refinements such as prioritizing interventions that were both policy-aligned and operationally feasible, rephrasing certain interventions to clarify their applicability, and omitting interventions deemed too theoretical or impractical. This process ensured that the Q-set captured both strategic considerations from a policy perspective and operational feasibility from an implementation perspective. The expert feedback was documented and used to develop the Q-set. The full table summarizing the feedback from the expert interviews, including the modifications made based on this input, can be found in Appendix E. The final Q-set, which includes 25 interventions, is now ready for use in the Q-sort. Table 4.1 provides an overview of these interventions. Participants will rank each intervention based on their perceived effectiveness, enabling an analysis of the perspectives on scaling circular procurement practices.

Table 4.1: The final Q-set

No.	Category	Intervention	Description
1	Finance	Establish financial implications	Map the financial implications of circular economy principles, including costs and benefits, to enable better decision-making.
2	Finance	Introduce financial incentives for circular performance	Introduce financial incentives to make circular practices more attractive, such as reducing the cost of second-hand materials.
3	Finance	Financial disadvantages for non-circular practices	Introduce financial penalties for non-circular practices, such as raising the costs of primary raw materials through higher taxes.
4	Knowledge	Train employees to learn benefits and practices for CE implementation	Make training on circular economy mandatory, ensuring employees understand the benefits, tools, and strategies for applying circular economy principles.
5	Knowledge	Establish and communicate best practices	Sharing successes and failures helps scale what works and prevents the repetition of the same mistakes.
6	Knowledge	Develop and disseminate consistent terminology	Develop and spread consistent terminology for circularity to promote collaboration and understanding, such as ”Het Nieuwe Normaal.”
7	Knowledge	Enhance knowledge and inspiration carousel events	Improve the depth of knowledge-sharing and inspiration sessions by bringing all relevant parties together in more focused gatherings.
8	Knowledge	Strengthen (digital) knowledge exchange	Create an online platform for structured knowledge exchange and support, similar to CROW.
9	Knowledge	International knowledge sharing	Share knowledge, experience, and materials internationally, for example, with Belgium and Germany.
10	Leadership and Strategy	Leading by example	Leaders must actively promote, assess, and discuss sustainability to motivate employees to take sustainability seriously.

No.	Category	Intervention	Description
11	Leadership and Strategy	Standardization of procurement strategy	Provide guidelines for sustainable procurement based on the experience of different public contracting authorities.
12	Leadership and Strategy	Determine responsible person for circular procurement policy	Appoint someone responsible for implementing circular procurement policies, preferably the same person responsible for general procurement policies.
13	Leadership and Strategy	Improve collaboration with market	Conduct market research and early consultations to validate circular needs and ambitions.
14	Policy and Regulation	Reevaluate frameworks	Revise policy documents and frameworks to enable the application of sustainable concepts and circular solutions.
15	Policy and Regulation	Monitor progress	Track and evaluate the progress of circular initiatives to make improvements and ensure the effectiveness of the measures.
16	Policy and Regulation	Allow space for alternative verification methods	Allow flexibility in verifying innovations, as they may not always be demonstrable through standard verification methods.
17	Organization	Implement transition management	Implement transition management to support the shift to circular practices and facilitate planned changes.
18	Organization	Inter-departmental coordination	Strengthen collaboration between departments, as the procurement team alone cannot implement circularity.
19	Organization	Introduction of early-phase advisors	Increase the use of sustainability advisors during the earliest phases of projects.
20	Implementation	Look beyond project boundaries with other clients and the market	Collaborate internally and with other clients and/or the market to enhance opportunities for reuse and resource matching.
21	Implementation	Upscaling pilot projects	Use pilot projects to gain experience with circular public procurement and share the lessons learned.
22	Implementation	Product-oriented standardization	Implement a product-oriented approach, such as IFD (industrial, flexible, and demountable), to improve standardization, reuse, and collaboration in the construction sector.
23	Implementation	Organize storage of materials at a regional or national level	Organize the storage of materials on a regional or national level to better facilitate reuse.
24	Implementation	Enhance Environmental Cost Indicator (MKI)	Include additional requirements for disassembly and standardization alongside the MKI.
25	Implementation	Portfolio / program approach	Use long-term contracts and framework agreements to make it more attractive for the market to invest in developing circular solutions.

4.3. Finalizing P-set

A total of 14 participants performed the Q-sort and accompanying interview. Table 4.2 provides a detailed description of each participant, including their organization, function group, work experience (in years), and specific experience with circularity. The participants were selected through a combination of attending a physical event of the ”Leernetwerkbijeenkomst Circulaire Viaducten en Bruggen” and through the professional network of my supervisor at Witteveen+Bos, ensuring a diverse and relevant sample for this research.

The functions of the participants vary quite widely, ranging from project managers and tender managers to sustainability advisors and innovation managers. This diversity in function groups is intentional, as it captures a broad spectrum of perspectives from different functional teams involved in circular viaducts and bridges. By including stakeholders from public authorities, market parties, and knowledge institutions, the study aims to cover all essential angles and insights related to the procurement and implementation of circular infrastructure.

During the Q-sort, 14 participants completed the activity, slightly exceeding the original target of 12 participants. Two additional participants, one from a market party and one from a provincial authority, were included at the recommendation of current participants due to their extensive knowledge on the subject. This resulted in a more comprehensive dataset, capturing a wider range of perspectives than initially planned.

Table 4.2: Overview of participants, with their function and experience with circularity

Code	Organization	Function Group	Work experience (years)	Experience with Circularity
RWS1	Rijkswaterstaat	Sustainability Advisors	2	Focuses on incentivizing circularity through procurement contracts.
RWS2	Rijkswaterstaat	Project Management	25	Leads a circular viaducts program at Rijkswaterstaat.
PRO1	Province of Overijssel	Project Management	18	Managed several circular viaducts and bridges projects.
PRO2	Province of Gelderland	Sustainability Advisors	23	Worked on circular viaduct and bridge projects.
PRO3	Province of Gelderland	Asset Management	2	Oversees asset management with experience in circular projects.
GEM1	Municipality of Rotterdam	Sustainability Advisors	24	Actively integrates circular elements into construction projects.
GEM2	Municipality of Rotterdam	Sustainability Advisors	29	Involved with the Buyer Group Circular Viaducts.
MA1	Closing the Loop	Project Management	8	Part of the SBIR Circular Viaducts and bridges initiative.
MA2	Combinatie Liggers 2.0	Tender Management	11	Part of the SBIR Circular Viaducts and bridges initiative.
MA3	Combinatie Liggers 2.0	Program Management	13	Part of the SBIR Circular Viaducts and bridges initiative.
MA4	ViCi	Project Management	15	Part of the SBIR Circular Viaducts and bridges initiative.

Code	Organization	Function Group	Work experience (years)	Experience with Circularity
KE1	TNO	Innovation Management	4	Expertise in IFD-building, beam reuse, and sustainable procurement.
KE2	Brugcampus	Program Management	10	Works on reusing residual streams for circular infrastructure projects.
KE3	IB Westenberg	Sustainability Advisors	30	Involved with the Buyer Group Circular Viaducts and CB'23.

4.4. Conducting Q-sort

The Q-sorts were conducted in person, with each session lasting about an hour. Participants were provided with printed cards representing the interventions, which they physically placed on a score sheet to rank them. An example of a completed Q-sort can be seen in Figure 4.2. After completing the Q-sort, participants were interviewed to discuss their rationale for ranking the interventions as they did and to identify any potential missing interventions.

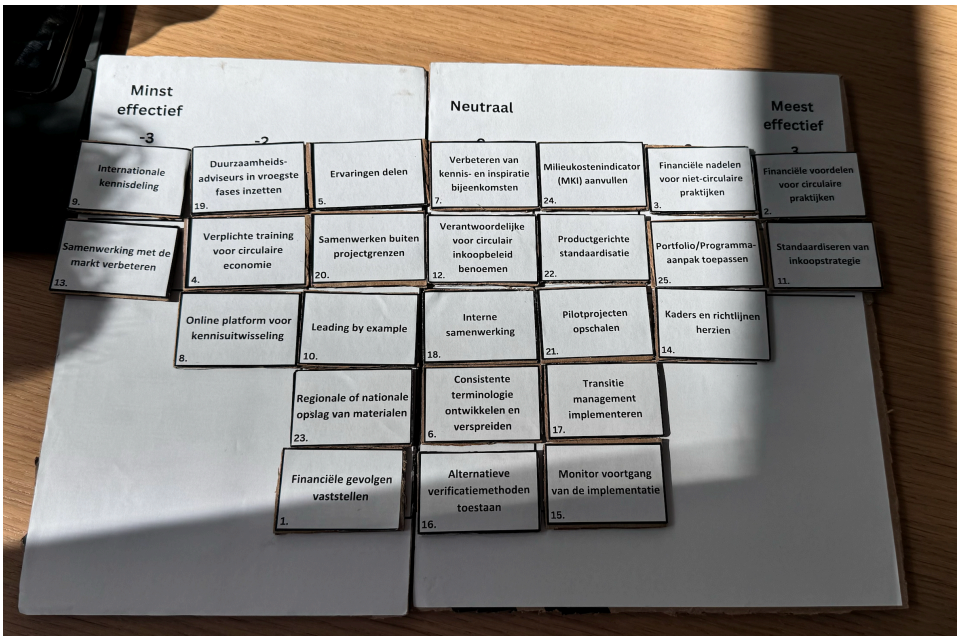

Figure 4.2: An example of a completed Q-sort

In three of the sessions, two participants conducted the sorting simultaneously. In these sessions, two separate sets of score sheets and intervention cards were provided to ensure independent decision-making. Participants were instructed not to communicate with each other during the sorting process to avoid influencing each other's rankings.

Following the completion of the Q-sorts, the data was entered into Excel. The sessions were also transcribed and coded in ATLAS.TI. This coding enabled a structured analysis of the participants' statements regarding each intervention and the corresponding scores they assigned.

4.5. Q-sort Analysis

The Q-sort analysis was conducted using KADE (version 1.3.1), an open-source software designed for Q-methodology data analysis.

4.5.1. Correlation between Q-sorts

The correlation matrix illustrating the relationships between different Q-sorts can be found in Appendix G. The correlations ranged from a high of 0.71 to a low of -0.50. It is important to note that the correlation matrix serves as an intermediate step, required to understand the underlying factor structure of the data. Subsequently, factors were extracted using the Brown Centroid Factor approach (Brown, 1993), and these factors were rotated using the Varimax Rotation Method to achieve clearer and more interpretable results.

4.5.2. Factor Extraction

The factor solutions were evaluated against seven predefined criteria to determine the most suitable solution, see table 4.3. The evaluation of each criterion is outlined below:

1. **Significant Q-Sorts:** The 2-factor and 3-factor solutions only have two acceptable factors. The 4-factor and 5-factor solutions each have three and four acceptable factors, respectively. The 6-factor and 7-factor solutions do not show significant improvement in the number of acceptable factors, having both four acceptable factors.
2. **Explain Variance:** The 5-factor solution explains 52% of the variance, meeting the minimum threshold of 50%. Although adding more factors increases the explained variance (e.g., 62% in the 7-factor solution), the increase is marginal beyond the 5-factor solution.
3. **Humphrey's Rule:** The 5-factor solution meets this criterion with four acceptable factors, indicating statistical robustness. The 6-factor and 7-factor only have three accetable factors according to this criterion.
4. **Simplicity:** While the 2-factor or 3-factor solutions are simpler, they may oversimplify the diversity of perspectives. The 5-factor solution, with four acceptable factors, strikes a balance between simplicity and comprehensiveness.
5. **Clarity:** The 5-factor solution achieves clarity by having 14 defining sorts, with only one non-loader and one confounder. This indicates that most participants have distinct viewpoints that align well with one of the factors
6. **Distinctiveness:** A correlation matrix is made for the 5-factor solution (see Table 4.4) shows generally low correlations, with the highest being 0.46 between Factors 1 and 4, indicating that the factors represent distinct perspectives. Factor 3 is excluded as it did not meet Humphrey's Rule and is thus omitted from the table.
7. **Stability:** Criterion 7 was not considered when deciding between the factor solutions as examination of criteria 1 to 6 already indicated that the 5 factor solution was preferable.

Table 4.3: Evaluation of Factor Solutions Against Criteria

Factor Solution	2	3	4	5	6	7
Number of acceptable factors (criterion 1)	2	2	3	4	4	4
Cumulative % of explained variance (criterion 2)	38	40	47	52	58	62
Number of acceptable factors (criterion 3)	2	2	3	4	3	3
Number of defining sorts (criterion 5)	-	-	-	14	14	14

Factor Solution	2	3	4	5	6	7
Number of non-loaders (criterion 5)	-	-	-	1	1	1
Number of confounders (criterion 5)	-	-	-	1	1	1

Table 4.4: Correlation Matrix of Factors in the 5-Factor Solution

	Factor 1	Factor 2	Factor 4	Factor 5
Factor 1	1	0.21	0.46	0.33
Factor 2	0.21	1	0.14	-0.09
Factor 4	0.46	0.14	1	0.33
Factor 5	0.33	-0.09	0.33	1

The 5-factor solution is selected for further analysis as it meets the criterion for an interpretable factor solution. It has four acceptable factors, with a cumulative explained variance of 52%. The third factor did not meet Humphrey's Rule and was therefore excluded.

4.5.3. Perspective Loadings

The four remaining factors in the 5-factor solution are herein known as 'perspectives'. Each representing a distinct viewpoint with at least two significant loadings. Participants with significant loadings, highlighted in blue, are aligned with a specific perspective. In total, four participants align with Perspective 1, four with Perspective 2, three with Perspective 3, and two with Perspective 4. Participant KE2 is identified as a non-loader, as they do not have a significant loading on any of the four perspectives.

Table 4.5: Significant loadings on each perspective

Q-sort	Perspective 1	Perspective 2	Perspective 3	Perspective 4
RWS1	0.60	-0.06	-0.04	0.25
RWS2	0.78	0.09	0.25	-0.06
PRO1	0.35	0.61	-0.32	-0.12
PRO2	0.26	-0.72	-0.00	0.00
PRO3	0.06	-0.06	0.67	-0.10
GEM1	0.19	0.72	0.22	0.01
GEM2	0.24	0.70	0.12	-0.02
MA1	0.70	0.14	0.41	0.07
MA2	0.58	0.11	0.54	0.42
MA3	0.20	-0.12	0.22	0.74
MA4	0.57	0.18	-0.10	0.22
KE1	0.12	0.15	0.64	0.04
KE2	0.38	0.18	0.25	0.17
KE3	0.08	0.01	-0.15	0.57
Total	**4**	**4**	**3**	**2**

5

Interpretation of Perspectives

This chapter interprets the results of the Q-sort analysis. Section 5.1 introduces the mean Z-scores of the 25 interventions from the Q-sort, which highlight how participants ranked each intervention by perceived effectiveness. Section 5.2 provides an interpretation of the four perspectives identified through the data analysis. Section 5.3 explores the non-loader, whose viewpoint did not align strongly with any of the four perspectives. Section 5.4 covers the consensus statements, highlighting areas of agreement across perspectives, while Section 5.5 offers a comparative analysis of the perspectives based on the six intervention categories. The chapter concludes with Sections 5.6 through 5.8, which address missing interventions, and the relationship between perspectives and participants' functional roles and experience.

5.1. Mean Z scores

The graph presented in figure 5.1, displays the mean Z-scores of the 25 interventions found in the Q-set. Mean Z-scores reflect the average perceived effectiveness of each intervention as ranked by the 14 participants in the Q-sort. A positive Z-score (with a maximum of +3) indicates that an intervention is viewed as effective , while a negative Z-score (with a minimum of -3) indicates a lower perceived effectiveness. The interventions are grouped into six categories: finance, knowledge, leadership and strategy, policy and regulation, organization, and implementation, each represented by a different color in the graph.

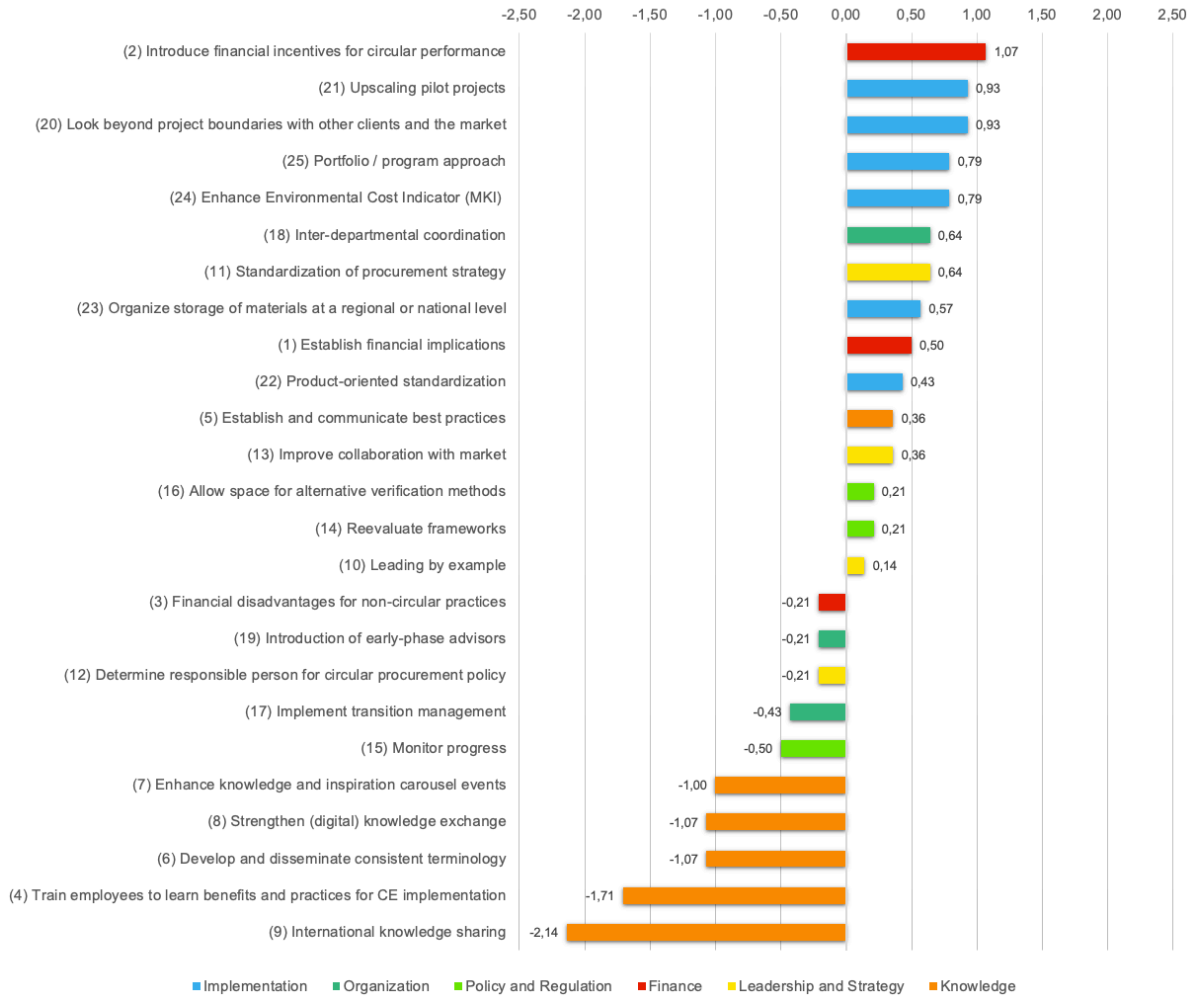

Figure 5.1: Mean Z scores across Q-sorts

The highest ranked interventions, those with the most positive Z-scores, predominately come from the finance and implementation categories. The top intervention, **"Introduce financial incentives for circular performance"** (Z = 1,07), is rated as the most effective strategy. This underscores the strong belief among participants that financial mechanisms are essential for scaling the procurement of circular viaducts and bridges. Other interventions in the top ranks, such as **"Upscaling pilot projects"** (Z = 0.93) and **"Look beyond project boundaries with other clients and the markt"** (Z = 0,93), point towards the value placed on practical, hands-on efforts to demonstrate and scale circularity. These results suggest that the participants view financial and implementation-based interventions as the most effective means to overcome the challenges related to up-scaling. However, with a mean Z-score of around 1, no single intervention stands out as a universally endorsed "must-do" action, indicating that participants see a variety of approaches as potentially useful but not overwhelmingly definitive in driving up-scaling.

A clear trend is observed in the ratings of practical-focused interventions, with these categories featuring the highest Z-scores. For example, interventions like **"Portfolio/program approach"** (Z = 0,79) and **"Enhance Environmental Cost Indicator (MKI)"** (Z = 0,79) further emphasizing the practical steps that the participants think will drive up-scaling.

Conversely, interventions related to knowledge-sharing are ranked significantly lower. The lowest-ranked intervention, **"International knowledge sharing"** (Z = -2.14, Knowledge), along with other low-scoring knowledge-related interventions such as **"Train employees to learn benefits and practices for CE implementation"** (Z = -1.71) and **"Develop and disseminate consistent**

terminology" (Z = -1.07), suggests that participants perceive knowledge-sharing efforts to be less critical in advancing circular procurement for viaducts and bridges. This may indicate a sentiment that sufficient knowledge already exists or that more immediate, action-oriented interventions are needed. Furthermore, the bottom two interventions have a mean Z-scores around -2. This suggests that participants generally do not see these knowledge interventions as essential for driving up-scaling, indicating a broad consensus that these approaches are not perceived as key factors in advancing procurement for circular viaducts and bridges.

In conclusion, the analysis of the mean Z-scores suggests that participants generally view financial and implementation-focused interventions as the most effective ways to scale CPP in the context of viaducts and bridges. Financial incentives and hands-on, demonstrative approaches, such as pilot projects, are particularly favored. Conversely, knowledge-sharing and training initiatives are seen as less critical, which may point to a belief that sufficient knowledge already exists or that more practical, actionable interventions are needed to drive circularity forward. These findings offer initial insights and serve as a baseline for exploring the four distinct perspectives in the next sections.

5.2. Perspective Interpretation

This section offers a summarized version of the interpretation of the different perspectives that surfaced from the Q-sort analysis. It captures how various stakeholder groups view the interventions for up-scaling the procurement of circular viaducts and bridges projects, drawing on insights and quotes from the post-Q-sort interviews.

For a more detailed exploration of the perspectives, please refer to Appendix H. The appendix provides an extensive analysis of the mean Z-scores and the most and least important interventions, including distinguishing statements that set each perspective apart. Table 5.1 provides an overview of the participants and the perspective they loaded onto.

Table 5.1: Overview of participants, with their function and perspective loading

Code	Organization	Function Group	Work experience (years)	Perspective Loading
RWS1	Rijkswaterstaat	Sustainability Advisors	2	Perspective 1
RWS2	Rijkswaterstaat	Project Management	25	Perspective 1
PRO1	Province of Overijssel	Project Management	18	Perspective 2
PRO2	Province of Gelderland	Sustainability Advisors	23	Perspective 2
PRO3	Province of Gelderland	Asset Management	2	Perspective 3
GEM1	Municipality of Rotterdam	Sustainability Advisors	24	Perspective 2
GEM2	Municipality of Rotterdam	Sustainability Advisors	29	Perspective 2
MA1	Closing the Loop	Project Management	8	Perspective 1
MA2	Combinatie Liggers 2.0	Tender Management	11	Perspective 3
MA3	Combinatie Liggers 2.0	Program Management	13	Perspective 4
MA4	ViCi	Project Management	15	Perspective 1
KE1	TNO	Innovation Management	4	Perspective 3
KE2	Brugcampus	Program Management	10	Non Loader
KE3	IB Westenberg	Sustainability Advisors	30	Perspective 4

5.2.1. Perspective 1

This perspective is characterized by its focus on immediate, action-oriented solutions to scale the procurement of circular viaducts and bridges. The participants in this perspective, including both

public contracting authorities from Rijkswaterstaat (RWS1, RWS2) and market participants (MA1, MA4), emphasize the need for flexibility in regulations, logistical coordination, and improvements to tools like the Environmental Cost Indicator (MKI) to drive practical progress. Participants in this perspective stress that the current regulatory framework must adapt to accommodate circular innovations, with less focus on theory or long-term knowledge dissemination and more emphasis on making tangible, hands-on progress. This perspective will from hereon be called **"Practical Circularity"**.

Most Important Interventions

1. **Allow Space for Alternative Verification Methods (Z = 1.39; distinguishing statement)**: This intervention, ranked as the highest priority, reflects the group's emphasis on flexibility in verification methods. Participants agree that traditional verification methods are unsuitable for circular construction, particularly when it involves innovative materials or processes. MA1 stresses that these technologies deviate from established standards, making it necessary to develop new verification methods: *"You can't just use standard provisions and verification methods. These materials don't come from the usual factory, so you need alternative ways to verify whether a beam is suitable."* Allowing these alternative approaches is seen as essential for validating new circular innovations, even if they initially require more time and resources. The shared perspective is that this flexibility is a critical enabler of circular procurement.
2. **Organize Storage of Materials at a Regional or National Level (Z = 1.37; distinguishing statement)**: Another high-priority intervention, is the storage at re regional or national level. RWS2 notes that effective storage solutions are essential for improving the business case of circular projects: *"In circular production, you're always dealing with matching materials between a donor project and a destination project. In between, materials need to be stored, and that storage process has a significant impact on the business case."* Both public and market participants acknowledge that circular procurement requires coordinated solutions for long-term storage, especially for complex materials like beams, which need to be stored for extended periods before reuse. This intervention underlines the practical need for infrastructure to support the logistics of circular material flow, ensuring the feasibility of scaling circular procurement.
3. **Enhance Environmental Cost Indicator (MKI) (Z = 1.23; distinguishing statement)**: Participants in this perspective see the MKI as a valuable tool, but believe it could be enhanced to better promote circularity, particularly by giving greater weight to reuse and circular materials. MA1 explains: *"If you increase the weight of the MKI, you can steer more towards reuse. It doesn't have to be reuse specifically; it can also contribute to sustainable work in other ways."* This suggests that while the MKI is already widely used and trusted, adjustments to the way it measures circularity could further incentivize sustainable practices. The use of the MKI highlights the group's focus on practical tools that can immediately support the transition to circular procurement.

Least Effective Interventions

1. **Financial Disadvantages for Non-Circular Practices (Z = 0.04; distinguishing statement)**: Participants generally favored rewarding positive behavior rather than penalizing non-circular actions. RWS1 advocates for the use of incentives, especially in the early stages of the transition to circular procurement: *"In this transition phase, you need both, but I think the advantages should weigh more."* This reflects the group's belief that incentives are a more effective tool than penalties for promoting innovation and encouraging stakeholders to adopt circular practices.
2. **Improve Collaboration with the Market (Z = -0.17; distinguishing statement)**: Views on market collaboration are mixed within this perspective. RWS1 underscores the importance of early engagement with the market through consultations to determine project ambition: *"Through market consultations, you can pick up early signals about how ambitious a project can be."* However, some market participants, like MA4, suggest that the public sector should take a stronger lead in defining the scope and framework for circular procurement, limiting the influence of market actors: *"The societal task should be leading, with the needs of the contracting authority at the center."* This tension reflects the group's concern that too much market influence could dilute the public sector's role in shaping circular procurement strategies.
3. **Standardization of Procurement Strategy (Z = -0.50)**: While standardization is acknowledged

as a helpful framework, participants feel that without clear investment commitments, it lacks effectiveness. RWS1 explains that uncertainty about investment volumes weakens the impact of a standardized procurement strategy: *"It gives the market some perspective, but it remains weak because the market doesn't know what to expect."* The group stresses that investment commitments are critical for ensuring that procurement strategies can effectively support circular procurement goals.

5.2.2. Perspective 2

This perspective includes participants GEM1, GEM2, PRO1, and PRO2, who focus on leadership, collaboration, and accountability to move circular procurement forward. They emphasize the need for assigning clear responsibilities, fostering collaboration across sectors and projects boundaries, and leading by example. This group sees circular procurement as a collective effort that requires shared goals and clear direction to succeed. This perspective will from hereon be called **"Collaborative Circularity"**.

Most Important Interventions

1. **Collaboration within the Market and Beyond Project Boundaries (Z = 1.92 & Z = 1.71; distinguishing statements)**: Collaboration is seen as a key driver for circular procurement. GEM1 stresses the importance of sharing knowledge and working together with other municipalities: *"You really can't do this alone; it's about sharing knowledge. We also notice at the municipal level that we can't do this alone. Other large cities are facing the same challenges, and there's a lot to learn from each other. Some cities are even ahead in certain areas, which makes collaboration so important in this transition."* Both public and private sectors must align, with the market playing a key role in determining feasibility. PRO1 reflects on a case where ambitious circular goals faced market hesitancy, showing the need for coordination on a larger scale to ensure success: *"You can't fully realize circularity within just one project; it needs a broader approach."*
2. **Determine a Responsible Person for Circular Procurement Policy (Z = 1.51; distinguishing statement)**: PRO1 highlights the need for accountability in driving circular procurement policies: *"Someone needs to be responsible for circular procurement policy; otherwise, it quickly fades away."* This intervention underlines the importance of leadership, ensuring that circular procurement remains a priority within an organization and is not overshadowed by traditional practices.
3. **Transition Management and Leading by Example (Z = 0.91 & Z = 0.98; distinguishing statements)**: Effective leadership and active transition management are seen as crucial for pushing the circular agenda forward. GEM2 emphasizes: *"If there's no leader pushing the transition, nothing happens."* PRO1 adds that the responsibility lies with the client to lead by example, particularly in managing the risks of circular innovations: *"As a client, I believe it's important to set a good example."* Participants agree that leadership is key in navigating the uncertainties of circular procurement, with contracting authorities taking the lead in setting the tone.

Least Important Interventions

1. **Enhancing the Environmental Cost Indicator (MKI) (Z = -1.01; distinguishing statement)**: Participants did not view enhancing the MKI as a critical intervention. GEM2 notes that while useful, the MKI only shows results at the end of the process: *"The MKI is nice, but at the end of the day, it only shows you the result."* They believe that it is not an active driver of circular procurement but rather a tool to measure environmental impacts post-procurement.
2. **Monitoring Progress (Z = -1.31)**: Participants downplay the importance of monitoring systems in driving circular procurement. PRO1 views monitoring as more of a political tool: *"It's good to monitor, but it's not going to drive a circular project."* They argue that practical action is more important than tracking progress, which is seen as less impactful in promoting real change.

5.2.3. Perspective 3

This perspective emphasizes the importance of internal coordination, standardization of procurement strategies, and reevaluating frameworks as key interventions for advancing circular procurement. Participants in this group, including representatives from knowledge institutions (KE1), market participants (MA2), and provincial governments (PRO3), stress the need for clear guidelines, consistent processes, and shared objectives to drive progress. By focusing on structural improvements within organizations and between stakeholders, this perspective highlights the role of internal collaboration and market certainty in achieving circular procurement. This perspective will from hereon be called **"Tactical Circularity"**.

Most Important Interventions

1. **Reevaluating Frameworks (Z = 1.58)**: Participants see this as the highest priority, especially when it comes to incorporating new, innovative materials into circular procurement. PRO3 points out the challenges posed by rigid safety regulations, which hinder the use of these materials: *"When dealing with bridges and viaducts, you're bound by strict laws and regulations, especially regarding safety. If you're working with innovative materials that aren't yet incorporated into the Eurocodes, you have to prove they meet strength requirements. That process is often time-consuming and costly, so it would be useful to have better guidance on how to manage this."* The need for leadership from larger municipalities and government bodies to drive the reevaluation of frameworks is also emphasized to ensure that even smaller municipalities can benefit from more flexible guidelines.
2. **Internal-Departmental Coordination (Z = 1.37; distinguishing statement)**: Achieving circular procurement is seen as heavily dependent on how well different departments within an organization coordinate their efforts. PRO3 stresses the importance of fostering a unified internal focus: *"If you can get everyone internally on the same page and working toward the same goal, you can achieve a lot together."* This internal collaboration ensures that circular goals are aligned across departments, creating a foundation for more effective procurement strategies.
3. **Standardization of Procurement Strategy (Z = 1.51)**: Standardizing procurement strategies is viewed as essential for providing market certainty and simplifying processes for circular procurement. KE1 explains that while flexibility in procurement can introduce variability, maintaining simplicity and modularity is key for longevity: *"The market works as you would expect: there's a tender, a question is asked, and the market does its best to meet that demand. But the more flexibility you allow, the more variation you get in the offerings. Sometimes that's good, but with circularity, and especially for bridges, it needs to be kept simple."* This approach ensures that even smaller municipalities with limited budgets can adopt circular practices without complexity.

Least Effective Interventions

1. **Implementation of Transition Management (Z = -0.98; distinguishing statement)**: Participants are skeptical about the role of a dedicated transition manager, seeing internal coordination as a more effective alternative. PRO3 remarks: *"I don't think you need a transition manager if internal collaboration is good."* While transition management provides a useful framework, participants believe that real progress depends on practical actions rather than simply adopting the concept.
2. **Financial Disadvantages for Non-Circular Practices (Z = -1.60)**: This intervention was also met with resistance. PRO3 acknowledges that raising the cost of primary raw materials could be a solution but notes that such measures are beyond the control of local governments: *"Raising the costs of primary raw materials through taxes could be a solution, but we as a province have no control over that."* The general consensus is that well-organized circular practices will naturally reduce the need for financial penalties.
3. **Organize Storage of Materials at a Regional or National Level (Z = -0.58; distinguishing statement)**: There is a split opinion on this intervention. MA2, representing the market, feels that leaving material storage to the market would avoid unnecessary bureaucracy: *"While I think the idea is good in principle, I believe that governments will only make it more complicated."* In contrast, KE1 argues that the market alone cannot address the complexities of storage logistics and that coordinated strategies are needed to ensure proper management.

5.2.4. Perspective 4

This perspective brings together participants MA3 and KE3, who emphasize the critical role of financial mechanisms, procurement standardization, and financial penalties in supporting circular procurement. The participants argue that creating financial incentives to reward circular practices, while penalizing non-circular behavior, is essential for making circular procurement financially viable and scalable. They also stress the importance of standardizing procurement strategies to ensure that circular methods become mainstream rather than isolated examples. This perspective will from hereon be called **"Financially-Driven Circularity"**.

Most Important Interventions

1. **Financial Incentives for Circular Performance and Financial Disadvantages for Non-Circular Practices (Z = 2.09 and Z = 1.39; distinguishing statements)**: Participants in this perspective strongly advocate for creating a financial environment that both encourages circular practices and discourages non-circular ones. MA3 highlights the current imbalance, where new materials are often cheaper and easier to procure, making circular materials less attractive: *"It's still quite easy to purchase new materials without being penalized for higher CO2 emissions. This makes circular materials less efficient and often more energy-intensive and expensive, not just in demolition or harvesting, but throughout the entire process."* The participants stress that financial mechanisms, such as CO2 taxes and weighted circular options in tools like the MKI, are needed to shift market behavior toward circularity. KE3 further emphasizes the importance of recognizing companies that exceed circular expectations: *"If a party takes more circular measures, they should get recognition or benefits for it. This encourages circular behavior and discourages non-circular practices."*
2. **Standardization of Procurement Strategy (Z = 2.09)**: Standardizing procurement strategies is seen as essential for advancing circular procurement at scale. MA3 explains that prescribing upfront decisions, such as harvesting reusable materials in every project, is necessary to ensure that circular materials are available for reuse: *"If you don't prescribe that upfront, there won't be enough material on the market."* KE3 adds that standardization provides consistency and predictability, making circular procurement accessible even to smaller municipalities: *"Standardization ensures that everyone knows how to procure circularly, making circular practices more widespread."* Both participants agree that a standardized approach will level the playing field and ensure that circular procurement becomes embedded in public infrastructure projects.

Least Effective Interventions

1. **Improve Collaboration with the Market (Z = -1.46; distinguishing statement)**: Participants in Perspective 4 rank market collaboration as one of the least effective interventions. MA3 argues that once the government commits to circular goals, such as those outlined in the Paris Agreement, they should move forward without waiting for market validation: *"If the government has committed to something, it should just happen, regardless of what the market thinks."* The participants believe that relying too much on market consultations will only delay the progress of circular procurement.
2. **Leading by Example (Z = -0.54)**: This intervention is also ranked as less important. MA3 expresses skepticism about the impact of symbolic leadership, suggesting that focusing on concrete actions, like procurement standardization, would be more effective: *"It's about putting words into action, not just symbolic leadership."* While KE2 acknowledges that leadership can motivate others, they agree that it is often inconsistent and depends on individual motivation.

5.2.5. Overview of Perspectives

Table 5.2 provides a final overview of the perspectives, as discussed in this section.

Table 5.2: Overview of extracted perspectives

Perspective	Description
Practical Circularity (Perspective 1) RWS1, RWS2, MA1, MA4	Focuses on practical, hands-on solutions for circular procurement, using flexible regulations and logistical coordination to achieve quick, scalable results. Prioritizes immediate, actionable interventions.
Collaborative Circularity (Perspective 2) PRO1, PRO2, GEM1, GEM2	Emphasizes leadership, shared responsibility, and collaboration between sectors to drive circular procurement. Focuses on collective efforts and accountability to achieve circular goals.
Tactical Circularity (Perspective 3) KE1, MA2, PRO3	Highlights the importance of standardization, internal coordination, and consistent processes to integrate circularity into procurement. Focuses on structured frameworks and internal collaboration.
Financially-Driven Circularity (Perspective 4) MA3, KE3	Advocates for financial incentives and penalties to promote circular procurement. Focuses on using financial mechanisms and procurement standardization to drive widespread adoption of circular practices.

5.3. The Non-Loader

KE2 is identified as a non-loader, meaning their Q sort did not correlate strongly enough with any of the identified perspectives to be grouped within them. As shown in the scatterplot in figure 5.2, KE2's viewpoint is closest to Practical Circularity (perspective 1), with a loading of 0.38. However, it does not meet the minimum threshold of 0,50 for any of the perspectives.

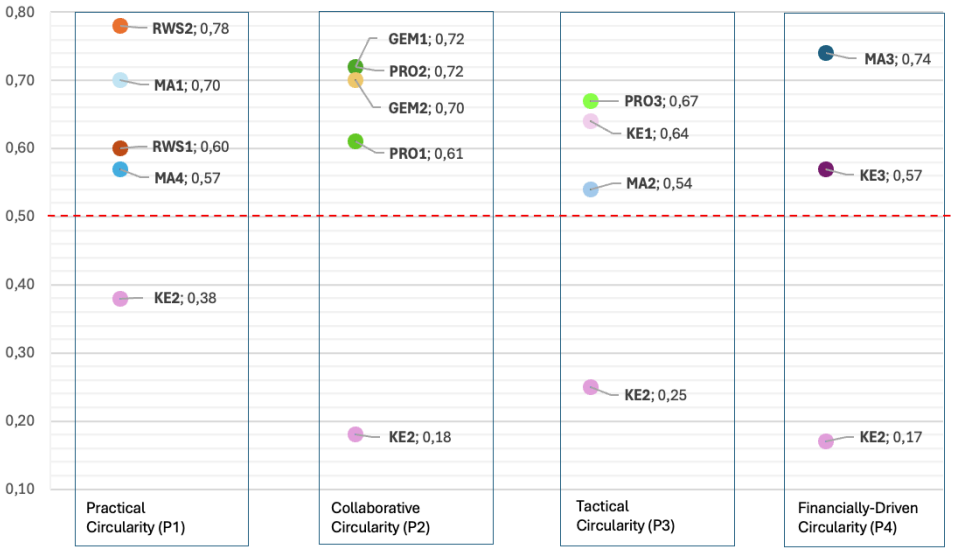

Figure 5.2: Scatter plot displaying the significant loadings of participants on each perspective, with KE2 identified as a non-loader across perspectives

While KE2's perspective shares commonalities with Practical Circularity, particularly in their emphasis on practical, action-oriented approaches, there are nuanced differences that set their views apart. One of the key distinctions in KE2's viewpoint is their strong belief in learning from mistakes and the need for stricter consequences when errors are repeated. KE2 expressed frustration with the current approach to sharing experiences, viewing it as too passive and insufficient for driving meaningful improvement.

They argue for a much more robust approach to ensure lessons from past procurement failures are not only discussed but acted upon, with significant consequences for those who repeat mistakes.

"What's important here is learning. So, evaluate: did you learn from the procurement you've done? We have famous examples like the North-South Line, but what have we learned from past procurements that we can now do differently? We tend to make the same mistakes over and over. It's about understanding the consequences of something going wrong. I'd want the lessons learned approach to be stricter. Right now, it's too soft."

This stance sets KE2 apart from others in the study, as they advocate for a more consequence-driven approach to procurement learning, in contrast to the more collaborative and flexible attitudes seen in other perspectives. KE2's perspective also emphasizes the importance of digital platforms and real-time data sharing to improve collaboration, distinguishing them from other perspectives. While KE2 aligns with the practical, hands-on solutions favored in Perspective 1, they place particular importance on the role of technology in driving collaboration and improving the efficiency of circular procurement processes:

"We need real-time data and digital platforms to track and coordinate materials. Without these tools, collaboration becomes much harder and less efficient."

In conclusion, while KE2 shares several viewpoints with other perspectives, particularly Perspective 1, they diverge in their focus on strict consequences for repeated mistakes and their focus on digital tools to enhance collaboration. These differences result in KE2 being identified as a non-loader, reflecting a unique stance that does not fully align with any of the identified perspectives.

5.4. Consensus Statements

Four consensus statements were identified in the Q-sort analysis. Consensus statements refer to those interventions where participants from all perspectives generally agreed on the effectiveness or lack thereof, leading to similar rankings across all perspectives. These statements help to highlight areas of broad agreement, even when participants may differ in their prioritization of other interventions.

Two consensus statements exist at the extreme less effective end of the Q-sort: **"International knowledge sharing" (Z = -2,14)** and **"Mandatory training of employees to learn benefits of circular economy" (Z = -1,71)**. One intervention was categorized as neutral in all Q-sorts: **"Establishing and communicating best practices" (Z = 0,36)**. Finally, one intervention consistently appeared as a moderately effective intervention across perspectives, but never as the most effective: **"Portfolio / program approach" (Z = 0,79)**. The mean Z scores of the consensus statements are visualized in figure 5.3.

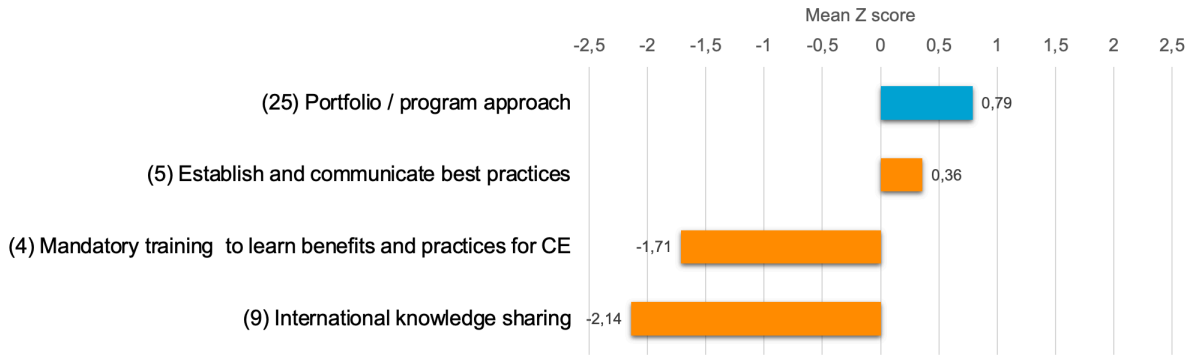

Figure 5.3: Mean Z scores for the four consensus statements

International knowledge sharing

International knowledge sharing was consistently ranked as one of the least effective interventions across all perspectives. This reflects a belief that domestic efforts should be prioritized before seeking international input. KE1 highlighted that while international knowledge is valuable, the focus should be

on consolidating national knowledge and practices first:

"Let's first focus on getting our own knowledge in order. There is certainly valuable international knowledge we can use, and we should definitely do that. But getting our own matters in order is even more important. We already know what we need to do here, so let's focus on that first."

This sentiment is shared across the perspectives, suggesting that while international collaboration could be beneficial, participants feel that the current priority should be on solidifying national efforts, learning from existing projects, and improving domestic circular procurement practices.

Mandatory training of employees

The second low-scoring intervention is the mandatory training of employees to learn the benefits of circular procurement. Across perspectives, there was agreement that mandatory training programs are unlikely to be effective because the shift toward circular practices should come from intrinsic motivation, not external pressure. This view is summarized by KE2:

"Mandatory courses or training won't help. I can already see that there are enough people who are genuinely motivated to change things. That group is now big enough to drive real change. It won't help to force people into mandatory training."

Participants suggest that there are already strong groups of motivated individuals, like the Buyer Group, pushing for circular procurement changes. Imposing mandatory training is unlikely to further accelerate the transition, as those who need it may not be receptive to it, while those already motivated don't require such measures.

Establishing and communicating best practices

Although establishing and communicating best practices was ranked neutrally across all perspectives, participants still acknowledged its importance. This intervention is not considered groundbreaking but is seen as a necessary step to reinforce confidence in circular practices, particularly for stakeholders who may still be uncertain or hesitant. One participant explained:

"I think it's important to share experiences. I've noticed that some clients are still struggling with this, which leads to some hesitation. When you can show that it's actually possible, and that it doesn't have to be too complicated, it works positively."

This suggests that even though the intervention is not seen as a top priority, it plays a supportive role in ensuring that stakeholders feel more comfortable adopting circular solutions by demonstrating that such approaches can work in practice

Portfolio / Program approach

The portfolio/program approach was consistently rated as moderately effective across all perspectives. It focuses on providing long-term contracts or framework agreements, offering market parties the certainty needed to invest in developing circular products. MA1 emphasized the importance of this long-term vision:

"What's most important here is the long-term vision. You can see this with the reuse of beams. If we want to do this efficiently—and efficiency also means doing it more cheaply—then you have to invest in an organization that is set up for this, such as in machines and workflows. And you're not going to make this kind of investment for an one-off project."

By guaranteeing a pipeline of projects over the next decade, the approach motivates investment in processes and infrastructure. This is highlighted by MA3:

"But if you know that, in the coming ten years, there will be so many viaducts, and that program will handle them, then it becomes worthwhile to invest in something. You can set up a team or even create a company around it."

This approach allows circular practices to scale efficiently, eventually competing with well-established linear methods.

5.5. Comparing Perspectives

This section presents a comparative analysis of the four identified perspectives on the needed interventions to upscale the procurement of circular viaducts and bridges. To visualize the score each perspective gives the different interventions, Figure 5.4 illustrates the mean Z-scores given to the 25 interventions across the four perspectives. These Z-scores represent the average effectiveness that participants from each perspective attribute to each intervention. A higher Z-score indicates a stronger perceived effectiveness of the intervention, while a lower Z-score reflects a lower perceived effectiveness.

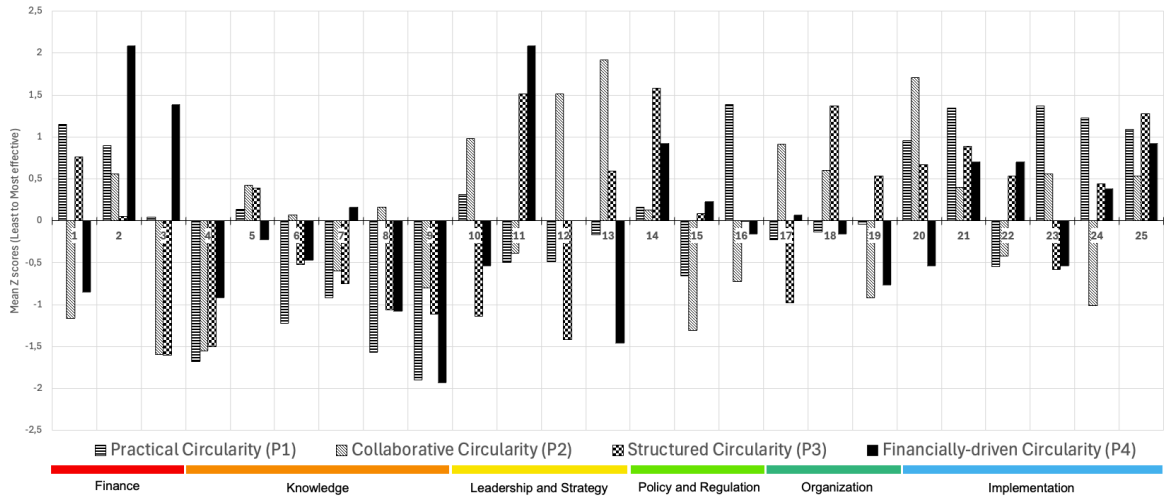

Figure 5.4: Mean Z-scores on the vertical axis represent the perceived effectiveness of 25 interventions along the horizontal axis. Compared between the four perspectives.

This comparative analysis aims to highlight both the commonalities and differences among the perspectives within each category. The following sections delve into each category, discussing how the perspectives align or differentiate:

5.5.1. Finance

The Finance category includes three interventions: (1) establishing financial implications, (2) introducing financial incentives for circular practices, and (3) imposing financial disadvantages for non-circular practices. In Figure 5.5, the horizontal axis represents each intervention within the Finance category, and the graph illustrates the mean Z-scores for these financial interventions across the four perspectives.

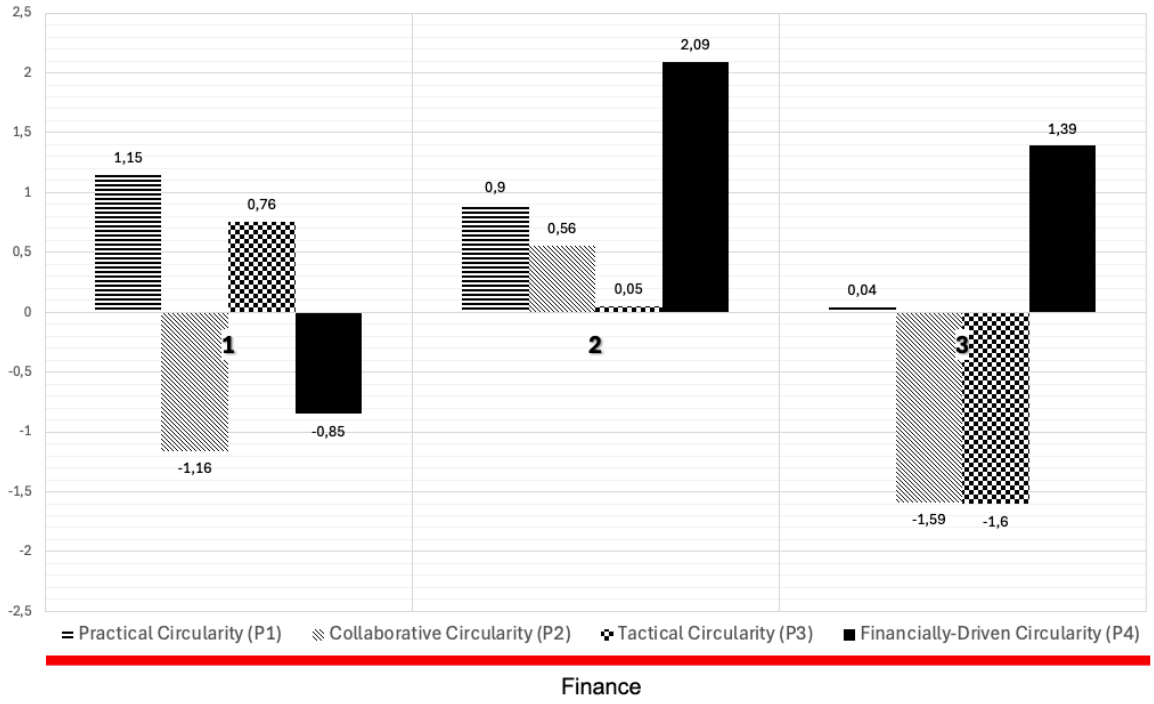

Figure 5.5: Perceived effectiveness of each finance intervention. Compared between the four perspectives

Similarities

All perspectives acknowledge that financial considerations influence the advancement of circular procurement. There is a shared understanding that financial mechanisms can affect behavior and decision-making within the sector. However, the degree to which each perspective prioritizes financial interventions varies.

Differences

The emphasis on financial mechanisms differs significantly among the perspectives. 'Practical Circularity' (Perspective 1) values understanding the financial implications of circular practices to make informed decisions. This perspective supports financial incentives that reward circular practices but is cautious about penalizing non-circular behaviors, favoring positive reinforcement over punitive measures. As MA1 from this group states:

"The financial consequences, and the costs and benefits, are important. If they have the tools and leverage to make decisions, that will help a lot. That's what is often missing. Clarity. That's why I rated this as most effective."

'Collaborative Circularity' (Perspective 2) places less importance on financial mechanisms, focusing instead on leadership, collaboration, and shared responsibility. Participants in this group are skeptical about the effectiveness of financial penalties and consider financial incentives secondary to fostering a collaborative environment that encourages circular procurement. PRO1 summarizes this view, saying:

"I would prefer to reward good behavior, rather than the opposite."

'Tactical Circularity' (Perspective 3) recognizes the role of financial considerations but prioritizes internal coordination and standardization over financial interventions. They believe that establishing clear processes and frameworks is more crucial than implementing financial incentives or penalties. KE1 emphasizes:

"But in fact, if you demand it, if you ask for it, if you design and tender in the right way, and if you have a good understanding of it, then you don't actually need incentives."

In contrast, 'Financially-Driven Circularity' (perspective 4) places the strongest emphasis on financial mechanisms. Participants advocate for both financial incentives to encourage circular practices

and financial penalties to discourage non-circular behaviors. They argue that creating a financial environment that rewards circularity and penalizes non-circularity is essential for driving market behavior and scaling up circular procurement. MA3 from this group strongly supports this view:

"Because right now, circular practices just don't take off automatically. A circular approach is simply more expensive than a new one. So, something is definitely needed to truly work circularly or to ultimately achieve those ambitions. That's why I consider it the most effective."

5.5.2. Knowledge

The Knowledge category includes six interventions: (4) mandatory training, (5) establish and communicate best practices, (6) developing consistent terminology, (7) enhance knowledge events, (8) strengthen digital knowledge exchange, and (9) international knowledge sharing. Figure 5.6 illustrates the mean Z-scores of these knowledge interventions across the four perspectives, with each intervention represented along the horizontal axis.

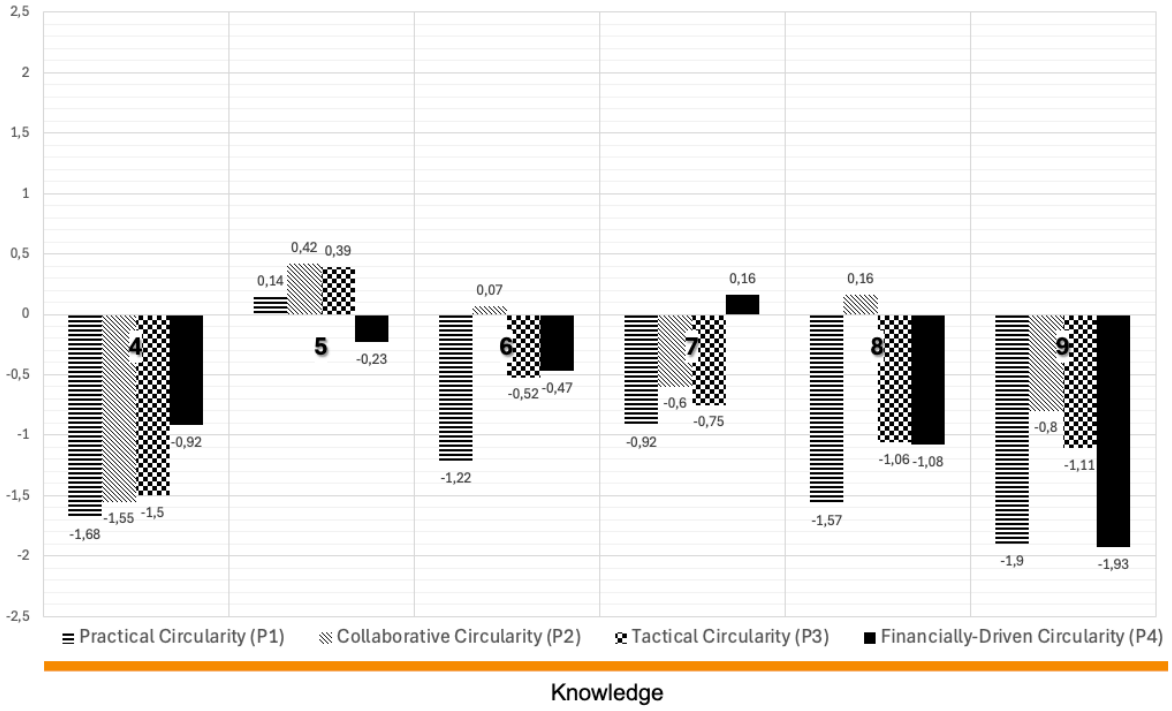

Figure 5.6: Perceived effectiveness of each knowledge intervention. Compared between the four perspectives

Similarities

There is general agreement across all perspectives that while knowledge sharing and consistent terminology are important, they are not the most critical interventions for advancing circular procurement at the stage we are currently in. Participants believe that mandatory training and international knowledge sharing are less effective compared to other interventions, and that intrinsic motivation is more influential than mandatory education.

Differences

Despite the consensus on the secondary importance of knowledge interventions, nuances exist in how each perspective views them. 'Practical Circularity' is cautious about investing heavily in knowledge-based interventions without immediate practical application, preferring action-oriented solutions over extensive knowledge exchange initiatives. RWS2 from this group expresses this:

"Sustainability is very patient. You can talk a lot about it, and it's great fun to talk about it. But whether it actually happens is the question. So, I would like to focus more on doing."

'Collaborative Circularity' values digital knowledge sharing as a component of collaboration but does

not see it as the main driver for change, viewing knowledge initiatives as supportive of collaborative efforts rather than standalone measures. GEM2 captures this idea by stating:

"It is important because many things have already been thought of. So, absolutely, yes, it should be done. But it's supportive, facilitating."

'Tactical Circularity' places relatively high emphasis on sharing best practices, seeing value in knowledge initiatives that support structured processes and organizational alignment. For PRO3, inspiring others plays an important role:

"It's worth showing other parties what's possible and inspiring them. I think it can contribute a lot, not only for market parties but also for society and even for politics."

'Financially-Driven Circularity' places less emphasis on knowledge interventions, focusing more on financial mechanisms and standardization. Participants may view knowledge sharing as beneficial, but insufficient to drive the necessary changes. MA3 explains:

"Yes, I think it's good that it exists. But it's not going to have a big impact on whether it is successful. No, it's more of a small component."

5.5.3. Leadership and Strategy

This category includes four interventions: (10) leading by example, (11) standardizing the procurement strategy, (12) determining a responsible person for circular procurement policy, and (13) improving collaboration with the market. Figure 5.7 shows the mean Z-scores of these leadership and strategy interventions across the four perspectives, with each intervention represented along the horizontal axis.

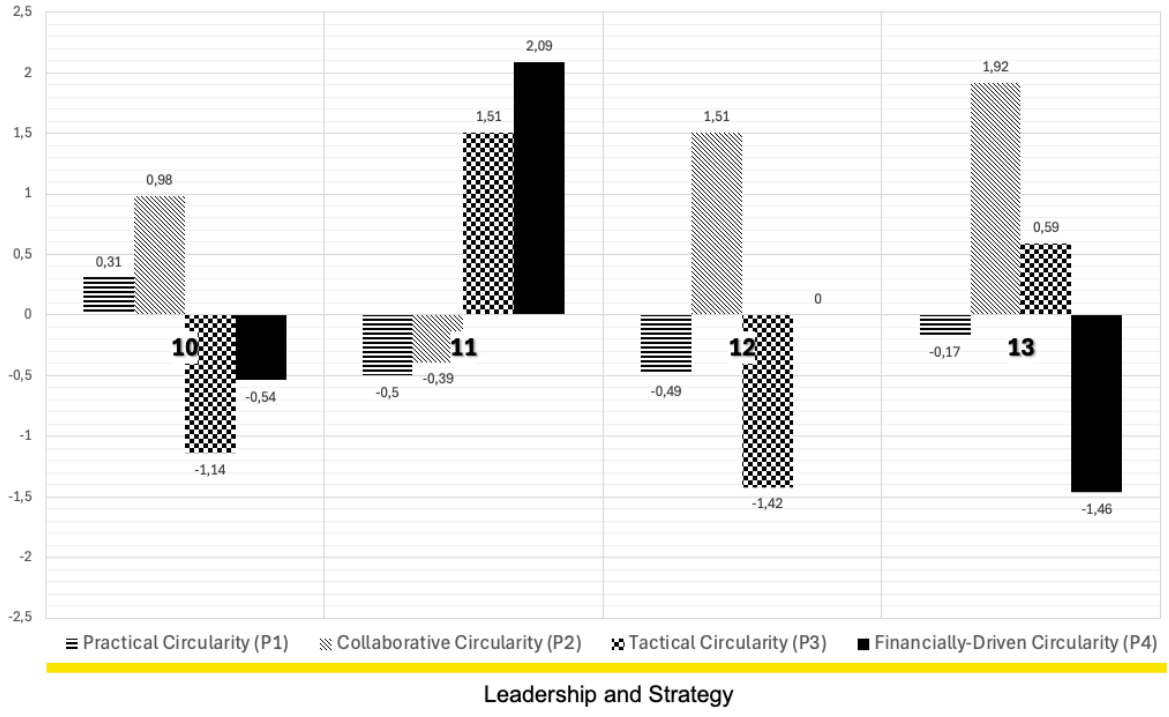

Figure 5.7: Perceived effectiveness of each leadership and strategy intervention. Compared between the four perspectives

Similarities

All perspectives recognize the importance of leadership and strategic direction but differ in how they believe leadership should manifest and influence circular procurement practices. There is a shared understanding that leadership plays a role in driving change, but the extent and manner of its influence vary.

Differences

'Practical Circularity' focuses less on leadership interventions, emphasizing practical actions over symbolic leadership and preferring immediate solutions that can be implemented without relying heavily on top-down directives. As RWS2 explains:

"Too much top-down can also lead to not being able to do things. You need to leave some room. Personally, I would prefer to emphasize implementation."

'Collaborative Circularity' places strong emphasis on collaboration and accountability. Participants in this perspective prioritize determining a responsible person for the circular procurement policy and improving collaboration with the market, indicating that they value accountability and collective efforts to drive the circular procurement agenda. They believe that assigning clear responsibility and fostering market collaboration are essential for achieving circular procurement goals. PRO1 underscores this by stating:

"Someone needs to be clearly responsible for circular procurement policy; otherwise, it quickly fades away. If there is not someone consistently pushing and emphasizing the importance of circularity, people will revert to the standard way of working, and circularity will soon disappear from view."

'Tactical Circularity' prioritizes standardization of the procurement process over assigning a single person responsible for the circular procurement policy or relying on leading by example. Participants in this group value structured processes and clear frameworks, believing that standardizing procurement strategies is more effective than depending on individual leadership to drive change. As KE1 explains:

"The market works as you would expect: there's a tender, a question is asked, and the market does its best to meet that demand. But the more flexibility you allow, the more variation you get in the offerings. Sometimes that's good, but with circularity, and especially for bridges, it needs to be kept simple. The design needs to be modular, longer-lasting, or capable of being renovated. That design decision always lies with asset management."

'Financially-Driven Circularity', similar to 'Tactical Circularity', is skeptical about the effectiveness of leading by example. This perspective favors structural changes and financial mechanisms over symbolic leadership, arguing that concrete actions, such as the standardization of the procurement strategy, are more impactful than relying on individual leaders. KE3 from this group supports this by stating:

"It's very important that everyone knows how to procure circularly, and for that, we need standardization so that everyone is more or less doing it the same way. Additionally, we need to set a realistic level that everyone can achieve. If that's done right, you can ensure that the majority starts procuring circularly, not just a few frontrunners."

5.5.4. Policy and Regulation

The policy and regulation category includes three interventions: (14) reevaluating frameworks, (15) monitoring progress, and (16) allowing alternative verification methods. Figure 5.8 illustrates the mean Z-scores of these policy and regulation interventions across the four perspectives, with each intervention represented along the horizontal axis.

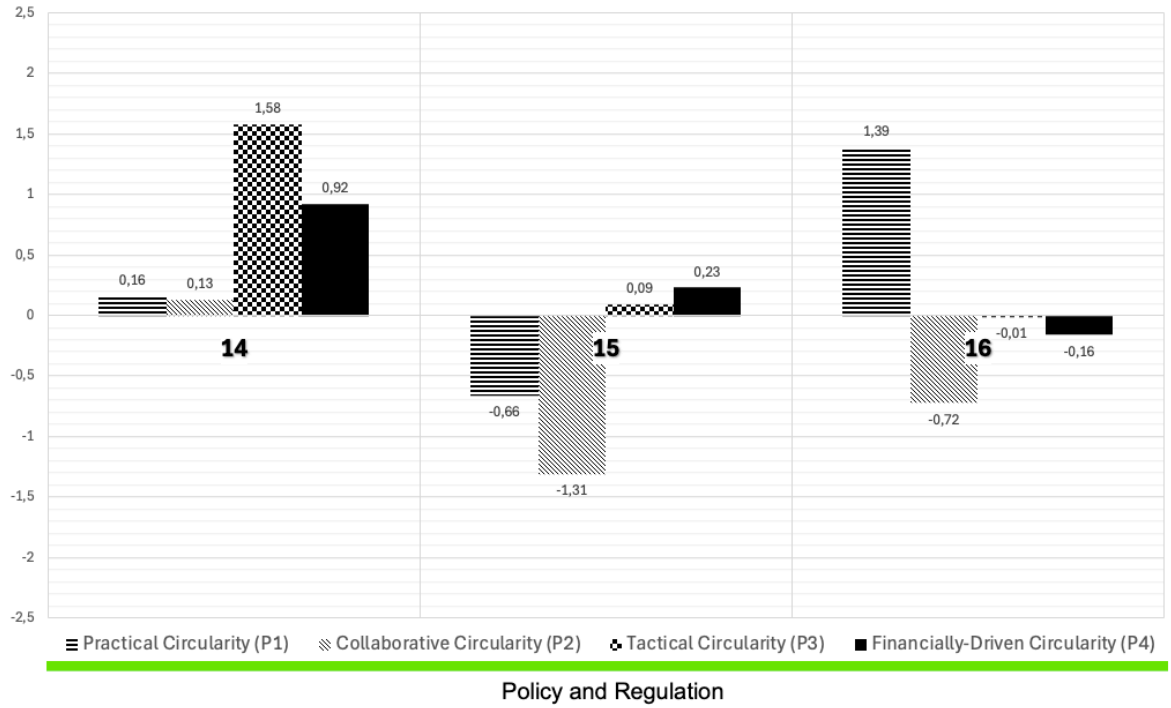

Figure 5.8: Perceived effectiveness of each policy and regulation intervention. Compared between the four perspectives

Similarities

All perspectives acknowledge the role of policy and regulation in facilitating circular procurement but differ in their emphasis on specific interventions within this category. There is general agreement that policies need to support circular practices, but the approach to policy changes varies.

Differences

'Practical Circularity' supports allowing alternative verification methods to enable practical implementation of innovative solutions. This perspective is cautious about rigid policies that may hinder flexibility, preferring regulations that accommodate innovation. MA1 explains the need for alternative approaches:

"In the beginning, this will cost more time and money because you can't simply check off a list; you actually have to do the calculations. But this is needed to demonstrate that it's possible and safe. Once this has been successfully proven several times, you can start developing new standards so that it eventually becomes the new norm. But the first step is to allow these alternative approaches."

'Collaborative Circularity' places less emphasis on policy interventions, focusing more on leadership and collaboration, and may view policy changes as necessary but not sufficient without accompanying leadership and collaborative efforts. PRO1 highlights this view:

"Yes, it's good to monitor what you've done, but I don't think it's going to be the driving force behind a circular project. It's more important to just take action and actually do it. Such a monitoring system might be nice for politics, to show what's been achieved, but for the actual implementation, it does not add much. It feels more like something for show than a tool to stimulate real change."

'Tactical Circularity' strongly advocates for revising frameworks and guidelines to support structured processes and standardization. Participants believe that policy changes are essential for providing

clarity and consistency, which are crucial for scaling circular practices. PRO3 emphasizes the importance of revisiting these frameworks:

"When dealing with bridges and viaducts, you're bound by strict laws and regulations, especially regarding safety. If you're working with innovative materials that aren't yet incorporated into the Eurocodes, you have to prove they meet strength requirements. That process is often time-consuming and costly, so it would be useful to have better guidance on how to manage this."

'Financially-Driven Circularity' also supports policy interventions that align with their emphasis on standardization and financial mechanisms, but they note that revising frameworks can be an ongoing process and should not be the top priority. KE3 sums this up by saying:

"I think we have enough frameworks and guidelines, and we can keep revising them infinitely. It's good, but for me, it's not the top priority. Let's focus more on doing, like pilot projects and sharing knowledge."

Policy and regulation shows a varying spotlight on flexibility versus standardization. 'Practical Circularity' and 'Collaborative Circularity' favor flexibility to accommodate innovation, while 'Tactical Circularity' and 'Financially-Driven Circularity' advocate for standardized frameworks to provide consistency.

5.5.5. Organization

This category involves three interventions: (17) implementing transition management, (18) inter-departmental collaboration, and (19) deploying early-phase sustainability advisors. Figure 5.9 illustrates the mean Z-scores of these organization interventions across the four perspectives, with each intervention represented along the horizontal axis.

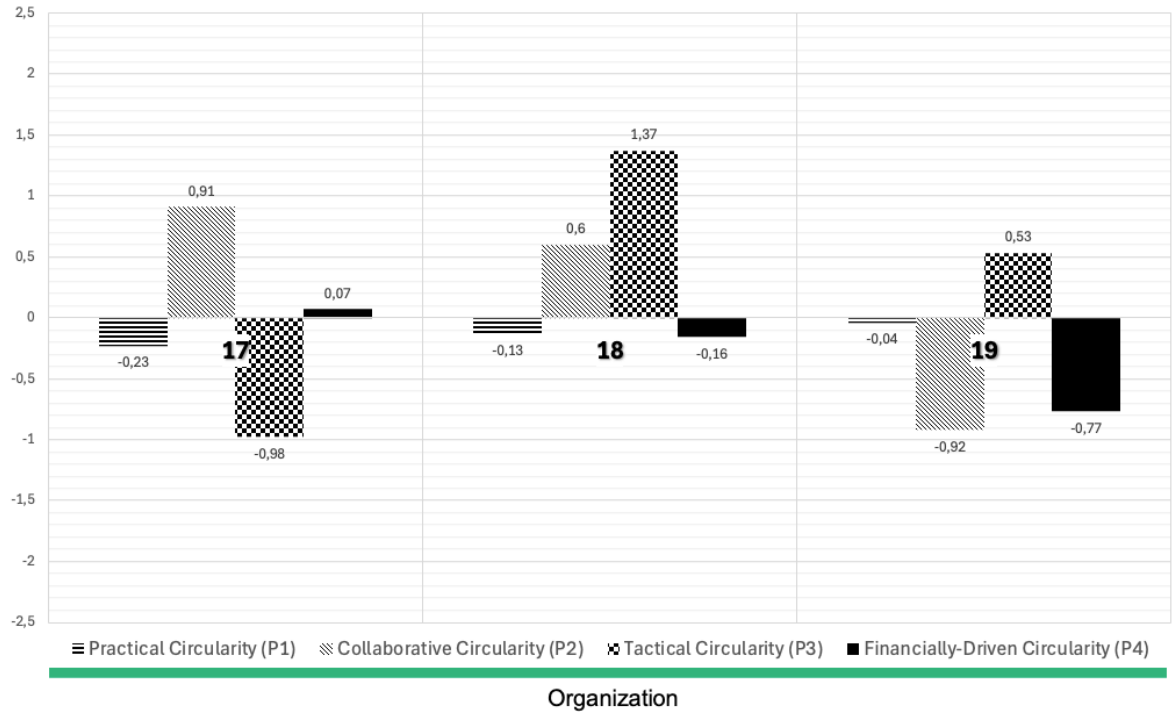

Figure 5.9: Perceived effectiveness of each organization intervention. Compared between the four perspectives

Similarities

There is general acknowledgment of the importance of organizational alignment and internal collaboration in advancing circular procurement. All perspectives recognize that how organizations are structured and operate internally can impact the effectiveness of circular procurement.

Differences

The perspectives differ in their emphasis on organizational interventions. 'Practical circularity' places importance on organizational changes, but focuses more on practical, immediate actions that can be taken without extensive coordination. RWS2 captures this viewpoint by saying:

"Implementing transition management is absolutely important too, but it's more of a general matter."

'Collaborative Circularity' values transition management as part of a broader emphasis on leadership and shared responsibility. GEM2 stresses the importance of leadership in driving this transition:

"I think it's very important that leaders emerge and really shape transition management. Without a leader pushing for the transition, it remains theoretical, and nothing happens. I think that's crucial, across the entire chain."

'Tactical Circularity' strongly stresses internal coordination, viewing strengthening internal collaboration as essential for implementing structured processes and achieving consistency across projects. PRO3 highlights the central role of internal collaboration:

"Internal collaboration is really the key for me. If you can get everyone internally on the same page and working toward the same goal, you can achieve a lot together. The success or failure of circular procurement depends on how well you can create that shared focus."

'Financially-Driven Circularity' places less importance on organizational interventions, focusing more on financial mechanisms and standardization. This perspective may believe that organizational changes will follow once structural and financial frameworks are in place. KE3 expresses this by saying:

"We keep reorganizing management, but just go and do it."

5.5.6. Implementation

The Implementation category includes six interventions: (20) collaborating beyond project boundaries, (21) scaling up pilot projects, (22) product-oriented standardization, (23) organizing storage of materials, (24) enhancing MKI, and (25) applying a portfolio or program approach. Figure 5.10 illustrates the mean Z-scores of these implementation interventions across the four perspectives, with each intervention represented along the horizontal axis.

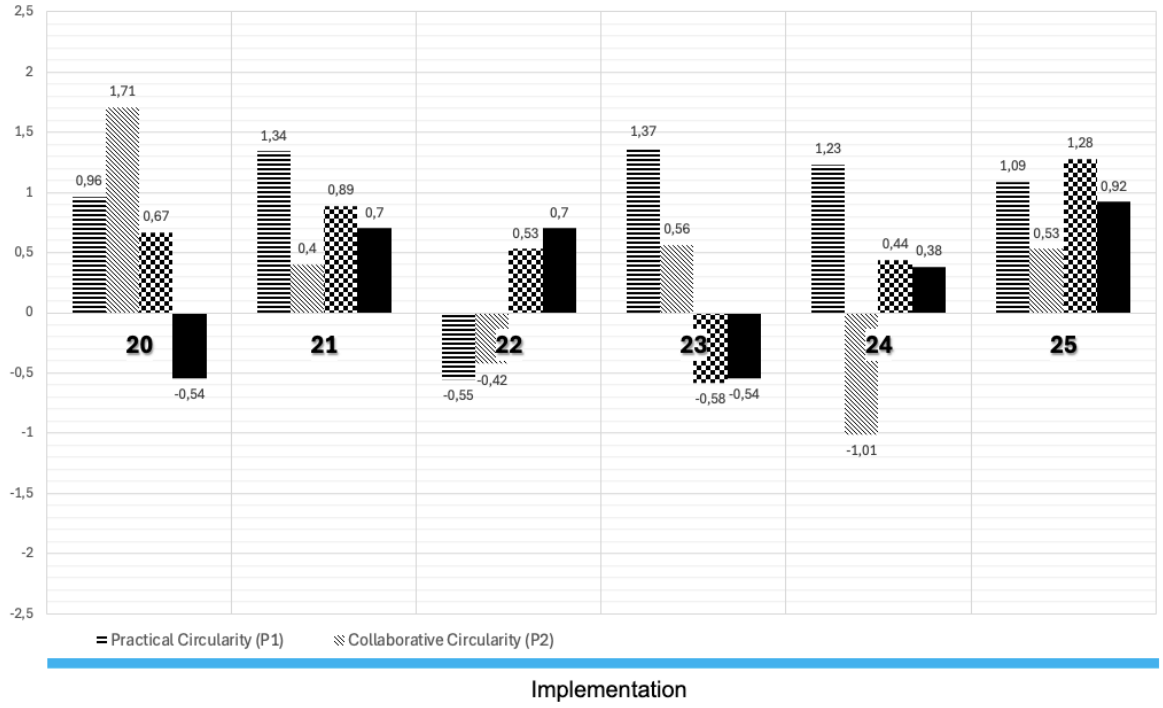

Figure 5.10: Perceived effectiveness of each implementation intervention. Compared between the four perspectives

Similarities

All perspectives support scaling up pilot projects and applying a portfolio or program approach, recognizing the practical benefits of these interventions in demonstrating feasibility, gaining experience, and providing market certainty. There is a shared understanding that practical implementation efforts are essential for advancing circular procurement.

Differences

The perspectives have different priorities regarding implementation methods. 'Practical Circularity' prioritizes practical, immediate actions that address current barriers, such as organizing material storage and enhancing the MKI, believing that hands-on solutions are necessary for progress. RWS1 emphasizes the importance of addressing storage challenges:

"If we don't take responsibility for storage, the business case currently becomes too risky. We have already had experiences where we had to pay extra because storage costs made the project financially unviable. This seems to be a crucial aspect."

'Collaborative Circularity' underscores collaboration beyond project boundaries, aligning with their focus on shared responsibility and collective action. Participants in this group value partnerships that increase opportunities for reuse and innovation. GEM1 highlights the need for collaboration across municipalities:

"You really can't do this alone; that's the core message. As GEM2 just mentioned, it's about sharing knowledge. We also notice at the municipal level that we can't do this alone. Other large cities are facing the same challenges, and there's a lot to learn from each other. Some cities are even ahead in certain areas, which makes collaboration so important in this transition."

'Tactical Circularity' supports implementation interventions that align with structured processes and standardization but is cautious regarding interventions like organizing material storage, fearing that it could overcomplicate things. MA2 expresses this concern:

"I placed this more to the left (indicating less importance), because while I think the idea is good in principle, I believe that governments will only make it more complicated if they handle it this way. The way I interpret it, it would no longer be the government's responsibility, and that seems overly bureaucratic to me. I think it would be better to leave this kind of thing to the market."

'Financially-Driven Circularity' supports implementation interventions that facilitate standardization but places less value on interventions requiring extensive collaboration or flexibility, such as collaborating beyond project boundaries. This perspective focuses more on concrete, structured approaches that can be implemented through standardization and financial mechanisms rather than broader, collaborative initiatives.

5.6. Missing Interventions

This chapter talks about the interventions that participants felt are missing from the Q-sort. Out of the fourteen participants, seven identified an intervention that could further support scaling the procurement of circular viaducts and bridges. The missing interventions that were suggest primarily are around two themes: organizational structures and material management. The following sections will dive intro these two identified themes.

Organizational structures

A recurring theme from several participants was the need to ensure that circular procurement is supported and integrated at various levels within organizations and across the supply chain. This theme, focused on organizational structures, emphasizes the importance of collective commitment and collaboration to ensure the success of circular procurement.

One participant from 'Collaborative Circularity', PRO1, highlighted the necessity for **organizational-wide commitment to circular procurement practices**. They argued that without a concerted effort across all levels of the organization, circular procurement could easily revert to standard practices when key stakeholders are not actively engaged. As PRO1 stated:

"You need to be supported by the whole organization with what you're doing. Otherwise, you do it once, and if no one cares, you'll revert back to the standard approach."

Additionally, GEM2 from 'Collaborative Circularity' emphasized the concept of "tier management" or **ketenopdrachtgeverschap**. They advocated for stronger collaboration throughout the entire supply chain, ensuring that both public and private sectors are involved in setting and achieving circular procurement goals. This idea of shared responsibility between clients and the market is seen as a crucial factor in sustaining circular procurement practices over the long term:

"Tier management is crucial for ensuring that the market remains viable while pursuing circular goals. It's important that everyone in the supply chain has a vested interest in circular procurement."

Another suggestion came from MA4 ('Practical Circularity'), who advocated for **alternative business models** that could better align with circular procurement principles. These models, such as "buy and repurchase" contracts or design-build-finance-maintain (DBFM) models, could provide financial incentives for reusing materials and promoting sustainability in the procurement process. This suggestion reflects the need for business approaches that support long-term circular procurement strategies. MA4 remarked:

"I've discussed other business models in the sector, like buy and repurchase or DBFM models, that could better incorporate circular material applications."

These suggestions collectively point to a broader need for organizational integration and stakeholder collaboration to ensure that circular procurement becomes a sustained and embedded practice, rather than a one-off project-based initiative.

Material management

Several participants stressed the need for improved systems to manage, track, and match reusable materials with relevant projects. This theme centers around increasing the visibility and transparency of available materials.

A suggestion from two participants, PRO1 ('Collaborative Circularity') and MA1 ('Practical Circularity'), was the creation of a **material marketplace or matching platform**. PRO1 explained:

"You need a better marketplace for materials, where something becomes available and can be applied elsewhere."

MA1 added that there should be more knowledge about material availability, and this information should be accessible to decision-makers to help match materials to projects:

"We need more knowledge of what's available and the ability to match it with projects to ensure reuse."

Building on this, KE2 (non-loader) emphasized the need for **improved material data management** to ensure decision-makers have access to detailed information about available materials, such as their location and potential for reuse. KE2 explained:

"It's important to know what materials are available, where they are located, and how they can be reused. This information should be integrated into procurement decisions."

KE3 ('Financially-Driven Circularity') suggested a more formalized version of this idea by highlighting the **material passport**, which would allow for better tracking of materials throughout their lifecycle, including their environmental impact. The material passport would provide a standardized way to track materials, ensuring transparency in procurement and allowing for more informed decisions about reuse. KE3 noted:

"You need to show how you're reducing environmental costs and how materials can be traced. This is essential for ensuring fair comparisons and making informed decisions."

Finally, MA3 ('Financially-Driven Circularity') called for proactive efforts to **harvest reusable materials** at the beginning of projects. They argued that by identifying and collecting reusable materials early in the process, there would be a greater supply of circular materials available for use in future projects. MA3 stated:

"If you want the market to adopt circular practices, you need to harvest reusable materials upfront. This will increase the options for using circular elements in projects."

These suggestions collectively point to the need for improved material management and tracking systems. By enhancing the visibility of reusable materials and providing clear tracking mechanisms, circular procurement can be more easily integrated into project planning and execution.

5.7. Perspective and Function Group

This section focuses on analyzing the functional composition of the participants within each perspective to understand how their professional roles shape their views on circular procurement interventions. Each of the identified perspectives includes participants from various functional backgrounds, such as Sustainability Advisors, Project Management, Tender Management, Asset Management, Innovation Management, and Program Management. Understanding how these functional group align with the priorities of each perspective provides insights into why certain interventions are emphasized over others. An overview of the found function groups in each perspective can be seen in figure 5.11.

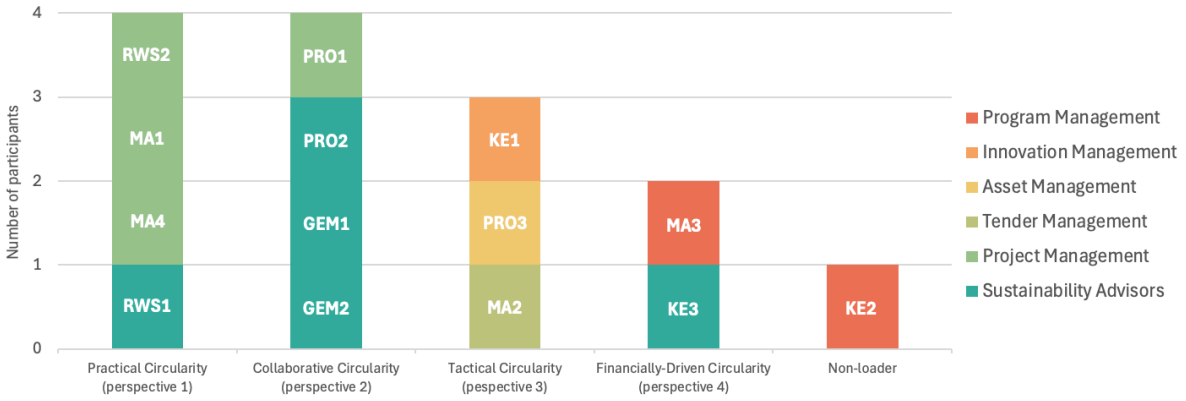

Figure 5.11: Function groups found in each of the four perspectives.

Practical Circularity (perspective 1)

'Practical Circularity' is primarily composed of participants with a background in Project Management, which includes three of the four participants in this group. This functional focus on project execution aligns with the perspective's hands-on, action-oriented approach to advancing circular procurement. Project Managers are often concerned with the immediate feasibility and logistics of project delivery,

which explains this perspective's preference for practical solutions like flexible regulations, material storage, and improvements to existing tools like the Environmental Cost Indicator (MKI). These professionals are likely to prioritize interventions that can be quickly implemented to address real-world challenges, such as organizing material storage and allowing alternative verification methods.

While RWS1, a sustainability advisor, holds a different role, their practical experience with projects like the 'RWS Groene Liggers' initiative, aimed at up-scaling the iniative from the SBIR, aligns them with the other members of this group. This hands-on involvement explains why RWS1, despite their advisory role, gravitates toward practical, actionable interventions. All four participants' direct involvement with circular viaducts and bridges projects further reinforces their shared commitment to solutions that prioritize immediate, actionable results.

Collaborative Circularity (perspective 2)

In contrast, 'Collaborative Circularity' has a strong representation of Sustainability Advisors, with three of the four participants coming from this functional group. Sustainability Advisors typically focus on long-term environmental goals and organizational collaboration, which fits well with this perspective's emphasis on leadership, collaboration, and accountability. These participants prioritize interventions that involve clear leadership roles, collective responsibility, and collaboration between the public and private sector. Their focus on fostering strong partnerships and ensuring accountability within organizations aligns with the typical responsibilities of Sustainability Advisors, who are often tasked with aligning projects to broader environmental goals.

Interestingly, this perspective includes four participants from municipal and provincial bodies, which could be explained by the fact that these local governments have not been as involved in large-scale circular viaduct projects as Rijkswaterstaat or the SBIR market parties. Without the direct experience of implementing large-scale circular infrastructure, and less available resources, municipalities and provinces are more likely to emphasize the need for collaboration and shared responsibility to drive these initiatives forward. This focus on coordination and leadership reflects their position of needing broader support and partnerships to initiate and scale circular procurement efforts.

Tactical Circularity (perspective 3)

'Tactical Circularity' has a blend of different functional groups, with participants coming from from Tender Management, Asset Management, and Innovation Management. Unlike other perspectives, the participants here seem to step beyond the confines of their specific roles, adopting a more holistic and strategic view of circular procurement. Rather than being narrowly influenced by their immediate functional responsibilities, these participants demonstrate more of a higher-level, systems-thinking approach, focusing on structured processes and the long-term integration of circular practices. This suggests that in this perspective, their functional background is less of a defining factor, as they have been able to look beyond their specific roles to view circular procurement challenges from a broader, more tactical standpoint.

An exception might be the Innovation Manager, for whom it is more natural to adopt a tactical approach that aligns with driving new methodologies and ensuring that innovative solutions are incorporated into standard practices. Innovation Management typically demands a balance between creativity and strategic implementation, which fits well with this perspective's emphasis on structured processes and procurement standardization.

Financially-Driven Circularity (perspective 4)

'Financially-Driven Circularity' is more difficult to generalize, as only two participants load significantly on this perspective. However, the presence of a Program Manager can be explained due program managers being responsible for overseeing entire programs with a clear emphasis on aligning long-term goals with financial viability. This likely explains the emphasis on financial incentives and penalties as key drivers for advancing circular procurement. Although the other participant in this group is formally categorized as a Sustainability Advisor, their current role is more aligned with that of a director, which may explain their focus on financial aspects. This shift in responsibilities toward strategic and financial oversight could account for the strong support for creating a financial framework that rewards circular behavior.

5.8. Perspective and Experience

This section provides insights into the distribution of experience across the four perspectives. The analysis shows some trends in terms of work experience. However, total years of experience do not necessarily reflect direct experience with circularity, as discussed earlier.

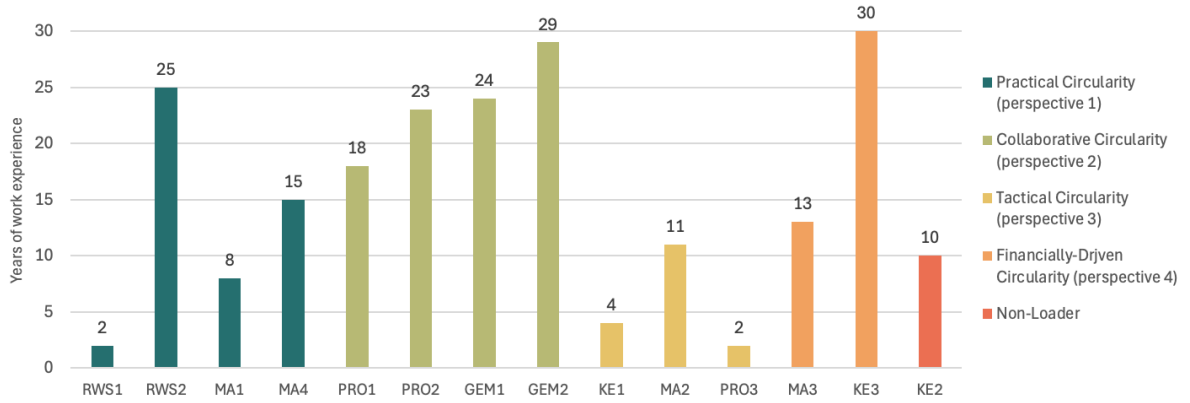

Figure 5.12: Experience of each participant, grouped in the four perspectives.

In 'Practical Circularity', there is a notable variety in the years of experience among participants. RWS1, for instance, has only 2 years of experience, while RWS2 has significantly more, with 25 years. Similarly, MA1 and MA4 fall in between with 8 and 15 years, respectively. This variation indicates that participants from this perspective come from a range of backgrounds, with both more and less experienced professionals contributing to practical, action-oriented approaches. This diversity suggests that both newer and more experienced professionals can find common ground in advocating for practical interventions.

'Collaborative Circularity' presents a different pattern, with participants generally having extensive years of experience. PRO1, PRO2, GEM1, and GEM2 have 18, 23, 24, and 29 years of experience, respectively, suggesting that participants in this group bring a high level of professional maturity to the table. This could be explained by the emphasis on collaboration, leadership, and accountability seen in this perspective. These qualities often develop over longer careers, where participants have likely had time to build strong relationships and networks across public and private sectors, which is central to the collaborative focus of this perspective.

Participants in 'Tactical Circularity' tend to have fewer years of experience, such as KE1 (4 years), MA2 (11 years), and PRO3 (2 years). This may relate to their recent academic backgrounds, where more focus has shifted to strategic and tactical approaches. Over the past decade, circularity has gained attention in academic settings. Though they have less experience in the field, their education likely covered modern trends and process-driven solutions. As a result, they focus on internal collaboration and standardization, and may take a broader view beyond their specific roles.

'Financially-Driven Circularity' similar to 'Collaborative Circularity', is composed of participants with significant years of experience. MA3 has 13 years, while KE3 has 30 years. The focus on financial mechanisms and standardization seen in this perspective might be due to a deeper understanding of long-term project costs and financial implications, which often comes with professional experience. These participants may have developed a greater understanding of how financial structures can drive circular procurement over their longer careers, or merely because of their roles (working in the private sector or a knowledge institution), making them more likely to advocate for these kinds of interventions.

6

Discussion

This chapter connects the findings from Chapter 5 to the literature discussed in Chapter 2. It starts by comparing theoretical-based and empirical-based interventions in section 6.1.1. Section 6.1.2 contrasts the literature's focus with that of the participants. Section 6.1.3 explores how institutional logics align with the extracted perspectives. Section 6.2 reviews missed interventions and links them back to relevant literature. The chapter then addresses the contribution to the literature in section 6.3 and concludes by outlining the research limitations in section 6.4.

6.1. Comparison with Literature

6.1.1. Theoretical-Based vs Empirical-Based Interventions

When comparing the inclusion of theoretical-based and empirical-based interventions, a clear pattern emerges (see Table 6.1 and 6.2). Empirical interventions were more frequently immediately included (54%) compared to theoretical interventions (35%), while theoretical interventions were more often included after modification (47%) compared to empirical interventions (31%).

Immediate Inclusion of Empirical Interventions

Empirical interventions tended to align more closely with the participants' real-world experiences, making them easier to adopt directly into the Q-set. These interventions, derived from examples and tested practices, offered tangible, actionable steps that could be readily applied within existing structures. For instance, empirical interventions like "Introducing financial incentives for circular performance" were directly included because they provided immediate solutions that participants could envision implementing.

Additionally, empirical-based interventions were often already familiar to the experts involved in the q-set development interviews. The two expert interviews put a greater emphasis on feasibility, filtering out interventions that seemed too distant from the current state of procurement. Therefore, empirical interventions were more likely to be recognized as viable within the existing frameworks, leading to their higher rate of direct inclusion.

Table 6.1: Inclusion of Empirical Interventions in Q-set

	Amount of Empirical Interventions	Immediate Inclusion in Q-set	Modified Inclusion in Q-set	Not Included in Q-set
Finance	5	2	2	1
Knowledge	9	4	4	1
Leadership and Strategy	5	5	0	0
Policy and Regulation	4	3	0	1
Organization	8	2	4	2
Implementation	4	3	1	0
Total	**35**	**19**	**11**	**5**
Percentage of total		**54%**	**31%**	**14%**

Modified Inclusion of Theoretical Interventions

On the other hand, theoretical interventions, although they address critical systemic barriers, often required being combined before they could be included in the Q-set. Theoretical interventions tend to be broader in scope or more abstract, making them less immediately actionable without modification.

For example, the theoretical intervention “Establish financial implications” was deemed important but had to be combined with Total Cost of Ownership (TCO) to become more relevant and actionable. This reflects how theoretical interventions often needed to be broken down into more specific items that could be practically applied within the Dutch procurement context.

Table 6.2: Inclusion of Theoretical Interventions in Q-set

	Amount of Theoretical Interventions	Immediate Inclusion in Q-set	Modified Inclusion in Q-set	Not Included in Q-set
Finance	3	1	2	0
Knowledge	4	2	1	1
Leadership and Strategy	3	0	1	2
Policy and Regulation	2	0	2	0
Organization	3	2	1	0
Implementation	2	1	1	0
Total	**17**	**6**	**8**	**3**
Percentage of total		**35%**	**47%**	**18%**

Category-Specific Insights

A particularly notable trend emerged in the leadership and strategy category: none of the theoretical interventions were directly included, while all of the empirical interventions were directly included. This reflects the fact that empirical interventions in this category provided clear, actionable steps that closely aligned with participants’ practical realities in circular procurement.

For example, the empirical intervention “Determine a responsible person for circular procurement policy” was directly included because it addressed a specific and urgent gap—namely, the need for accountability within organizations. In contrast, theoretical interventions like “Top-level management support” were perceived as too general and distant from participants’ immediate responsibilities, leading to their modified inclusion.

An interesting insight here is that 'leading by example' is considered an empirical intervention. While leading by example is frequently discussed in sustainability literature, it had not been explicitly linked to (circular) public procurement in the literature review. However, during empirical research, it became clear that leadership actions like this were important to advancing circular procurement, particularly through practical demonstrations of success. This led to its inclusion as an empirical intervention.

6.1.2. Literature Focus vs Participant Focus

This section delves into differences and commonalities between the existing body of literature on CPP and the empirical findings derived from the Q-sort analysis of stakeholder perspectives. While the literature provided a broad theoretical framework for understanding the barriers and interventions necessary for CPP, the perspectives of participants shed light on the practical realities of implementing these interventions within the infrastructure sector in the Netherlands. Two categories, finance and organization, aligned closely across both frameworks. Both literature and participants highlighted the importance of financial mechanisms and the inherent risk aversity, particularly among smaller public contracting authorities. However, significant divergences emerged in the remaining categories, which are discussed below.

Knowledge

A noticeable difference between literature and empirical findings was found in the Knowledge category. Much of the literature published between 2006 and 2018 on CPP identifies knowledge gaps, a lack of awareness, and limited experience as significant barriers ((Bouwer et al., 2006; Butler & Keaveney, 2014; Cheng et al., 2018; McMurray et al., 2014)). These works suggest that increasing knowledge and providing training are key interventions to overcoming these barriers.

However, much of this literature, dating back to around 2014, may no longer accurately reflect the current realities of the Dutch infrastructure sector, which has progressed beyond this initial phase. In contrast, participants in the Q-sort placed less emphasis on knowledge-related interventions. While participants acknowledged the importance of knowledge, they generally considered it secondary to more immediate concerns, such as financial mechanisms and practical coordination.

This discrepancy can be explained by the fact that the Netherlands' infrastructure sector has moved beyond the initial phase of knowledge gathering, as reflected in the empirical data. The sector's stakeholders may feel that basic circular principles are well understood, and the current priority is to focus on action-oriented interventions that address immediate implementation challenges rather than continuing to focus on knowledge dissemination. This divergence suggests that while knowledge dissemination was critical in earlier stages of CPP development, practical concerns now dominate stakeholders' priorities.

Leadership and Strategy

The literature emphasizes top management support as a critical intervention for CPP. Brammer and Walker (2011) and Smith et al. (2016) highlight that strong leadership is necessary for integrating circular practices into procurement, as strategic ambition can overcome inertia and drive sustainable practices. Leadership is often portrayed as setting the tone for circular procurement, providing the necessary political and administrative support to ensure that circular goals are implemented (Bloch & Bugge, 2013; Cheng et al., 2018).

Although participants recognized the importance of leadership, the empirical findings suggested a more nuanced view. Expert interviews conducted before the Q-sort revealed that top management support was not necessarily missing in the Netherlands, but rather the issue lay in the disconnection between management and the execution of circular strategies. Participants emphasized the need for clearer accountability at the operational level, with interventions such as appointing a responsible person for circular procurement policy being highly rated.

This highlights a gap in the literature, which tends to focus more on leadership at the tactical level, while the empirical findings suggest that connecting leadership to on-the-ground execution is equally, if not more, critical. The literature may overemphasize strategic ambition without adequately addressing how leadership must translate into practical, operational outcomes.

Policy and Regulation

A recurring challenge identified in the literature is the rigidity of policy and regulatory frameworks that fail to support circular procurement. For instance, Bloch and Bugge (2013) argue that inflexible rules around material reuse and certification create barriers for circular innovation. Regulatory standards often favor virgin materials, complicating the adoption of circular practices ((Zu Castell-Rüdenhausen et al., 2021)).

The participants echoed these concerns but were divided on how to address them. 'Practical Circularity' and 'Collaborative Circularity' highlighted the need for flexible regulations to accommodate innovative materials and processes, while 'Tactical Circularity' and 'Financially-Driven Circularity' emphasized the importance of standardization to provide clarity and consistency.

This division suggests a fundamental tension in how stakeholders envision regulatory reforms. While innovation requires flexibility, standardization is critical for creating clear and actionable guidelines, especially for scaling circular solutions beyond niche projects. The literature rightly highlights the rigidity of existing regulations, but empirical findings suggest that balancing flexibility with standardization will be essential for advancing circular procurement.

Implementation

The literature on implementation was often broad and lacking in specific guidance, especially when addressing the unique challenges of the Dutch infrastructure sector. However, Havinga et al. (2023)'s study, although not specific to procurement, emphasizes the importance of standardization, repeatability, and long-term partnerships.

This aspect resonated with participants. The portfolio/program approach intervention, which focuses on creating long-term contracts that incentivize investment in circular practices, was one of the positively rated consensus statements among participants. This reflects a shared understanding that scaling circular procurement requires structured, repeatable processes, rather than ad-hoc, project-based solutions.

6.1.3. Institutional Logics vs Extracted Perspectives

This section explores how institutional logics provide a framework for interpreting and contextualizing the stakeholder perspectives identified in this study. Institutional logics represent broad, socially constructed frameworks that influence organizational norms and priorities, while perspectives on interventions reflect actionable viewpoints shaped by stakeholders' roles and immediate contexts. By situating the extracted perspectives within these broader logics, this analysis seeks to uncover how shared values and norms intersect with the practicalities of advancing circular procurement. The discussion avoids equating perspectives with institutional logics, instead using the latter as a lens to understand how deeper organizational frameworks may inform, constrain, or align with the perspectives observed.

In connecting Tom Coenen's institutional logics with the extracted perspectives from the Q-sort analysis, varying degrees of alignment and gaps can be observed. Notably, certain institutional logics are more prominent, while others are underrepresented, influenced by the roles and positions of the participants. The diagram (Figure 6.1) provides a visual overview, mapping the institutional logics present within each of the four identified perspectives in the procurement stage.

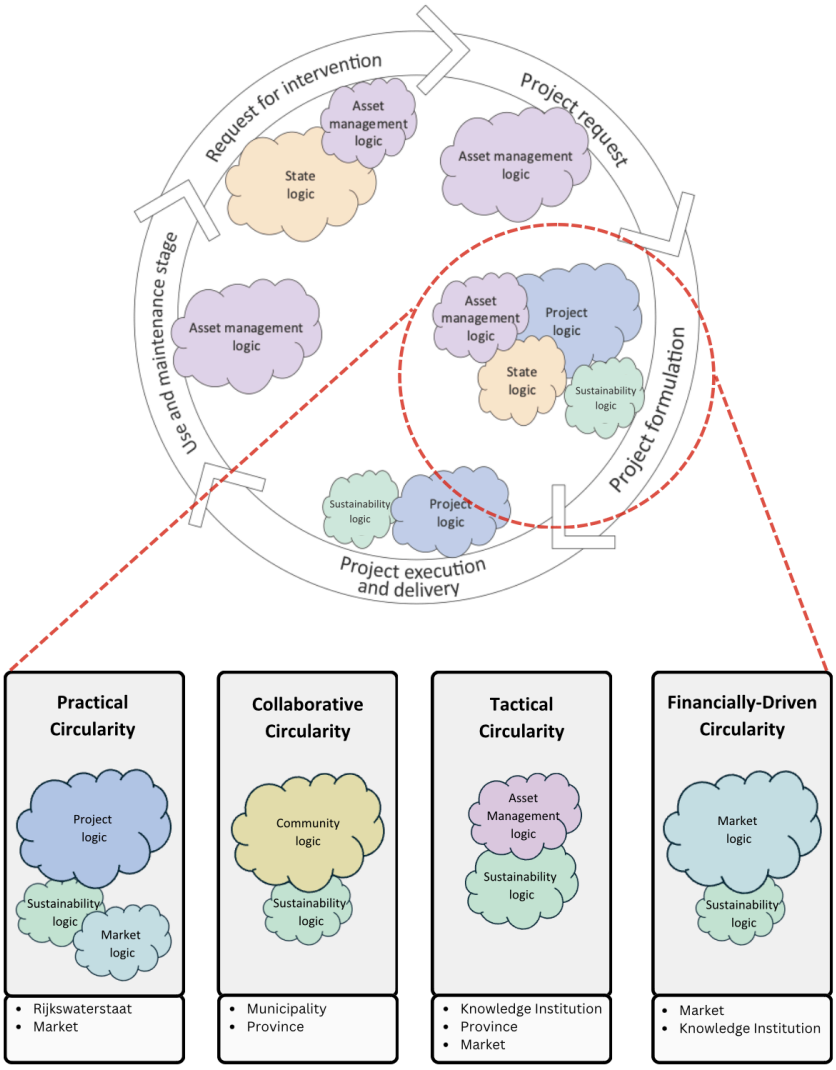

Figure 6.1: Institutional logics found in each of the four perspectives

State Logic

State Logic, characterized by procedural adherence and regulatory compliance over innovation, is primarily associated with executive management and bureaucratic functions. In this study, State Logic is underrepresented because the participants did not include high-level executives who typically embody this logic. For instance, in 'Tactical Circularity', there is an emphasis on standardization and internal coordination, reflecting elements of State Logic. However, participants advocate for reevaluating frameworks to enable innovation, suggesting a shift away from rigid adherence. The underrepresentation of State Logic can be further explained by the research methodology and the nature of the participants. Since participants were asked to prioritize interventions to improve the current process, they were inclined to focus on change and innovation, leaving less room for traditional, rigid views. Additionally, the participants have already had experience in circular projects, indicating they may hold more progressive views that challenge conventional State Logic. This combination of factors contributes to the limited presence of traditional State Logic in the extracted perspectives.

Asset Management Logic

Asset Management Logic focused on long-term preservation and risk aversion. This logic is naturally less evident in perspectives on upscaling circular viaducts and bridges, as circular initiatives often involve increased risks and questions about longevity. Parts of this logic can be found in 'Tactical Circularity' standardizing procurement strategies, internal coordination, creating clear guidelines

and reevaluating frameworks to accommodate innovative materials while ensuring asset reliability. This reflects a balance between maintaining asset integrity and adopting new practices for circular procurement. Notably, one asset manager took the q-sort (PRO3) and is part of perspective 3. Which may explain the presence of the Asset Management Logic in this perspective.

Project Logic

Project Logic, defined by short-term, task-oriented decision-making, is prominent in 'Practical Circularity'. Participants from Rijkswaterstaat (RWS1, RWS2) and market parties (MA1, MA4) focus on practical, immediate solutions such as pilot projects and flexible verification methods. This reflects a project-centric approach where efficiency and timely delivery are prioritized. The participants' roles in project management, explain the focus on Project Logic, emphasizing actionable strategies over long-term systemic change. However, it is worth noting that implementing alternative verification methods could require systemic changes, indicating that while the approach is project-focused, it may have broader implications for organizational practices.

Sustainability Logic

In this study, Sustainability Logic is present in all four perspectives, though its expression varies. While Coenen's definition emphasizes innovation and long-term responsibility, most of the perspectives in this research focus more on practical implementation than high-level innovation or stewardship. Participants reacted to interventions aimed at upscaling circular procurement, which inherently involves sustainability. However, their approach tended to prioritize actionable, immediate solutions over broader, strategic sustainability goals. Although the precise focus on innovation and long-term responsibility is not as dominant as in Coenen's definition, the underlying goal of all perspectives is inherently sustainable. Since the research centers on interventions for circular viaduct and bridge procurement, every perspective operates within a framework of environmental responsibility, even if the term "sustainability" is not always explicitly highlighted. Thus, Sustainability Logic is woven into each perspective, while reflecting the practical, action-oriented nature of most participants. Among the perspectives, Tactical Circularity reflects the most alignment with Coenen's definition of Sustainability Logic. This perspective focuses on internal coordination, standardization, and accommodating circular materials, balancing operational reliability with the need for long-term environmental stewardship.

Market logic

Market Logic, focusing on profitability and competition, is strongly represented in 'Financially-Driven Circularity'. Participants MA3 and KE3 advocate for financial incentives and penalties to drive market behavior towards circular practices. Interestingly, out of the four market parties who participated in the Q-sort, only one (MA3) represented the perspective strongly related to Market Logic. This indicates that individuals are influenced by factors beyond their organizational affiliation. Personal experiences, roles, and individual values can lead participants to align with different logics, regardless of the type of organization they work for.

Community logic

Community Logic, emphasizing collaboration and shared norms, is evident in 'Collaborative Circularity'. Participants from municipalities and provinces (GEM1, GEM2, PRO1) believe that upscaling circular procurement requires collective efforts and knowledge sharing across sectors and regions. This perspective reflects a strong commitment to mutual support and cooperation, essential for systemic change. The underrepresentation of Community Logic in other perspectives may be traced back to the function roles of participants. Those in project management or market roles may prioritize immediate objectives over collective efforts, leading to a lesser emphasis on Community Logic in their perspectives. 3 out of 4 participants on 'Collaborative Circularity' are sustainability advisors which may indicate their preference for mutual support and cooperation.

6.2. Missed Interventions

During the Q-sort process, several participants identified interventions that were missing from the final Q-set, particularly regarding tier management and material tracking and matching systems. These highlight both potential gaps in the research design and interesting avenues for future research and practice in circular procurement.

Tier Management

Two participants mentioned the need for 'tier management' (or ketenopdrachtgeverschap) within the supply chain. This intervention, while not present in the final Q-set, reflects an emerging trend in literature—especially concerning multi-tier supply chains. Notably, this concept did not appear in either the initial theoretical framework or empirical data collection phases. However, existing literature supports its potential relevance.

For instance, Kannan (2021) emphasizes that extending supply chain management to multiple tiers can yield significant sustainability benefits. Multi-tier systems encourage more integrated collaboration, allowing for a holistic approach across the entire supply chain. This is particularly relevant for circular procurement, where the coordination between suppliers, contractors, and public agencies is crucial for closing material loops and promoting circularity.

In the context of Dutch infrastructure projects, tier management is noticeably absent. Dutch infrastructure procurement typically focuses on traditional, linear supply chains where responsibilities are clearly delineated. However, the adoption of multi-tier management could be a transformative approach, enabling a more cohesive strategy for circular procurement that enables collaboration across all levels of the supply chain. Given the increasing complexity of supply chains in large infrastructure projects, integrating tier management into circular procurement practices could be a promising area for further exploration and practical implementation.

Material Tracking and Matching Systems

Three participants also underscored the need for better systems to track and match reusable materials with relevant projects. This intervention reflects a practical challenge: ensuring the visibility and traceability of materials for reuse across different projects. While material management was included in the Q-set as part of the broader intervention on organizing material storage at a regional or national level, the emphasis was primarily on storage rather than on tracking and matching.

In hindsight, separating these into two separate interventions would have provided a more comprehensive set of tools for addressing material reuse challenges. These mechanisms ensure that materials can more easily recovered and reintegrated into future projects, thus reducing waste and increasing circularity.

Other sectors, such as the construction sector, have already advanced in implementing material tracking systems, providing valuable knowledge on managing material flows and ensuring reuse (Heeren & Hellweg, 2019; Nasir et al., 2010). The infrastructure sector could benefit from leveraging these insights to establish efficient tracking and matching mechanisms.

The decision to prioritize storage in the final Q-set may have oversimplified the issue. Material tracking extends beyond logistics, it is an important enabler for effective reuse. Developing sophisticated data management systems that capture information about material condition, location, and potential applications is key to ensuring that materials can be matched with appropriate projects.

6.3. Contribution to Literature

As Sönnichsen and Clement (2020) noted, the existing body of literature on CPP remains limited, particularly in terms of empirical evidence and practical insights. One of the contributions of this thesis is the creation of an inventory of interventions that can support the upscaling of circular procurement. This inventory was built from a combined approach, integrated both theoretical and empircal research. The combination of these approaches allowed for a more complete understanding of how circular procurement can be promoted, and importantly, where theory and practice diverge. This research identified specific gaps, most notably in the knowledge category. Where theoretical literature overemphasizes the importance of knowledge dissemination, empirical data suggested that

the Dutch infrastructure sector has moved beyond this stage. By capturing the real-world perspectives by stakeholders, this thesis provides a richer, more context-sensitive set of interventions.

Building on recent work by Tom Coenen, who identified dominant institutional logics in the infrastructure sector, this research not only confirmed the presence of these logics but also introduced important nuances. For example, the project logic Coenen associates with project managers was clearly reflected in the Practical Circularity perspective in this study, which emphasizes hands-on solutions and short-term, task-oriented approaches. However, this research also brings new insights into Coenen's framework. While market logic might typically be expected to dominate among private sector participants, only one of the four market participants in this study reflected a strongly market-driven perspective. This finding suggests that stakeholders' decision-making processes are influenced by more than just their organizational role or institutional logic. Participants may embody multiple logics simultaneously or shift their perspective depending on contextual factors such as project demands or their collaboration with public entities. This adds a dynamic and multi-layered dimension to Coenen's framework, indicating that the application of institutional logics requires flexibility and attention to individual and situational contexts.

An important note is the appearance of community logic, which was only briefly mentioned by Coenen but was notably present in the smaller public contracting authorities, provinces and municipalities. These smaller public bodies emphasized collaboration and shared responsibility more strongly than larger Rijkswaterstaat or market parties. This focus on collaboration may stem from the fact that smaller public authorities often have fewer resources which makes partnership-building and shared initiatives critical for achieving their circular procurement goals. These entities tend to rely on collective efforts to pool expertise, overcome capacity limitations, and align with broader policy frameworks, reflecting the need for a collaborative, community-driven approach in scaling circular procurement at local levels.

Moreover, the identified perspectives can either complement each other or, at times, work against each other depending on how they are aligned within the procurement process. When structured effectively, perspectives such as Practical Circularity and Collaborative Circularity can help drive progress by combining practical action with collaborative leadership. However, without careful coordination, perspectives like Tactical Circularity and Financially-Driven Circularity could clash, as their focus on standardization and financial control might limit the flexibility needed for innovation. Recognizing these dynamics is essential for developing strategies that leverage the strengths of each perspective while minimizing conflicts.

A methodological contribution of this research is the application of Q-methodology to extract and analyze stakeholder perspectives on circular procurement. Q-methodology has not previously been applied in the context of circular public procurement, and it provided a structured way to map the range of opinions and priorities among stakeholders. By using this technique, this research went beyond merely listing interventions and instead offered a deeper understanding of how these interventions are perceived and valued by different key stakeholders.

6.4. Research Limitations

- This study involved 14 participants, which, while sufficient for a Q-sort methodology, is on the lower side. A larger pool of participants might have revealed additional perspectives or provided more nuanced insights into existing ones. The small sample size also limits the generalizability of the findings, particularly as the participants were not selected based on strict functional roles. Due to the niche focus of the topic and the timing of data collection (August), no stringent participant criteria could be applied. A more proportional distribution of roles across different organizations (e.g., project managers, sustainability officers, asset managers) may have enriched the results by capturing a broader range of viewpoints and professional experiences. Future research should consider targeting a larger and more functionally diverse participant base to ensure a wider range of perspectives.
- The focus on circular viaducts and bridges was primarily centered around the reuse of materials, with limited attention given to other circular practices such as bio-based materials. This focus might have restricted the scope of interventions considered during the Q-sort. By concentrating on reuse, other relevant dimensions of circular procurement, were not fully explored. Future

studies could expand the focus to include these aspects, providing a more holistic view of circular procurement in infrastructure projects.

- Due to the limited availability of literature on CPP specifically within the infrastructure sector, the research relied heavily on empirical data. Theoretical literature was drawn from related fields like GPP and SPP, but there was an inherent challenge in adapting these frameworks to the niche context of circular viaducts and bridges. This reliance on empirical findings may have led to an overemphasis on current practices, rather than identifying potential future trends or theoretical advancements in CPP. While the empirical approach resulted in valuable insights, the limited theoretical base highlights a gap in the literature, suggesting a need for more research on CPP within the infrastructure domain.
- The dynamic and evolving nature of circular procurement posed a challenge during the research period. Notably, key reports and literature became available after the thesis commenced, such as Tom Coenen's PhD dissertation on the transition to a circular infrastructure or the Buyer Group's Circular Viaducts and Bridges Procurement Strategy. These developments led to a shift in focus from initially developing a procurement framework to analyzing available information and gathering stakeholder perspectives. As a result, the study's scope was more reactive to emerging data rather than proactive in shaping the research direction from the outset. While this allowed for the inclusion of relevant, up-to-date information, this meant the research took a bit longer to complete. Future research should consider how to better anticipate and integrate ongoing developments into the research design.
- The concept of institutional logics emerged later in the research process, limiting its integration into the study. Institutional logics were used as a lens to contextualize stakeholder perspectives. While institutional logics and perspectives are related, they are not the same, as logics represent overarching organizational norms while perspectives focus on specific, actionable insights. Earlier incorporation of this framework could have allowed for more targeted questions and deeper analysis of how institutional logics influence circular procurement practices. Future research should position institutional logics as a core element to better contextualize their impact on interventions and organizational behavior.

7

Conclusion

This chapter addresses the main research question of this thesis:

> *"What are the different perspectives of key stakeholders on the interventions needed to upscale the procurement of circular bridges and viaducts by public contracting authorities"*

The chapter begins with section 7.1, which addresses the sub-questions and the main research question. Section 7.2 provides recommendations for practice. Finally, section 7.3 outlines recommendations for future research, highlighting areas for further exploration.

7.1. Addressing the Research Question

This research set out to explore the different perspectives of key stakeholders on the interventions needed to upscale the procurement of circular bridges and viaducts by public contracting authorities. The main research question is supported by four sub-questions, which are answered below, followed by a conclusion of the primary research question.

SQ1: What are the barriers to applying circular public procurement by public contracting authorities, and what interventions can be drawn from this?

The study identified six categories of barriers to CPP: finance, knowledge, leadership and strategy, policy and regulation, organization, and implementation. Key challenges for implementing CPP include the high perceived costs of circular solutions, lack of awareness and experience in circular practices, insufficient top-level management support, restrictive regulatory frameworks, limited organizational capacity, and the lack of standardized approaches in procurement. Addressing these barriers, 17 interventions were gathered, focusing on measures such as incorporating life-cycle costing to account for long-term savings, offering training programs to bridge knowledge gaps, enhancing inter-departmental and inter-organizational coordination, and implementing pilot projects to demonstrate circular procurement's potential. These interventions aim to support public contracting authorities in overcoming the existing challenges and up-scaling the adoption of circular procurement practices. For a detailed overview, see section 2.2 and table 2.4.

SQ2: How can Q-methodology be applied to capture the perspectives of key stakeholders on the interventions for upscaling circular procurement?

This study applied Q-methodology through five steps: concourse development, Q-set selection, P-set selection, Q-sort, and data analysis. A broad concourse of interventions was compiled from literature and empirical sources and refined into a representative Q-set with expert input. Key stakeholders, including public authorities, market parties, and knowledge institutions, formed the P-set. Participants ranked the interventions during the Q-sort exercise, reflecting their prioritization and perspectives. The analysis identified distinct stakeholder perspectives, providing insights into varied priorities for circular procurement. Further methodological details are outlined in Chapter 3.

SQ3: What interventions are identified in empirical documents for upscaling the procurement of circular bridges and viaducts?

Empirical documents specific to the Dutch infrastructure sector identified 31 interventions addressing barriers to circular procurement for viaducts and bridges. These interventions span the same six categories. Interventions include financial incentives for circular performance, regional material storage facilities, improved knowledge-sharing systems, and long-term framework agreements for circular innovation. These practical interventions highlight the need for structural changes in procurement strategies and the integration of circular principles into contracts, knowledge systems, and collaboration mechanisms. A detailed list of these interventions is provided in Appendix C.

SQ4: How do the identified perspectives of key stakeholders compare, and what insights can be drawn?

The analysis revealed four distinct perspectives among stakeholders, each with unique priorities:

1. Practical Circularity: Focuses on immediate, hands-on solutions like flexible regulations and improved logistics to address current challenges.
2. Collaborative Circularity: Emphasizes the importance of leadership, cooperation, and shared responsibilities across sectors to advance circular procurement.
3. Tactical Circularity: Highlights the need for standardized frameworks, structured processes, and internal coordination to scale circular practices effectively.
4. Financially-Driven Circularity: Centers on financial incentives and penalties as key drivers for adopting circular procurement practices.

While these perspectives reflect varied priorities, they share a common goal of overcoming barriers to circular procurement. These differences provide insights into the diverse ways stakeholders approach scaling circular practices.

Main research question: What are the different perspectives of key stakeholders on the interventions needed to upscale the procurement of circular bridges and viaducts by public contracting authorities?

The main findings of this study identified four distinct perspectives on interventions for upscaling the procurement of circular viaducts and bridges. Which are summarized in Table 7.1.

Table 7.1: Overview of the four perspectives and their characteristics

	Practical Circularity	**Collaborative Circularity**	**Tactical Circularity**	**Financially-Driven Circularity**
Description	Focuses on immediate, actionable solutions such as flexible regulations and logistics.	Emphasizes leadership, collaboration, and shared responsibility across sectors.	Centres on structured processes, standardization, and internal coordination for scaling circular practices.	Highlights the use of financial mechanisms, such as incentives and penalties, to drive circular procurement.
Participants	RWS1, RWS2, MA1, MA4	GEM1, GEM2, PRO1, PRO2	MA2, PRO3, KE1	MA3, KE3
Function Groups	Project Manager (3), Sustainability Advisor (1)	Sustainability Advisors (3), Project Manager (1)	Innovation manager (1), Asset Manager (1), Tender Manager (1)	Program Manager (1), Sustainability advisor (1)
Years of Experience	2-25 years	18-29 years	2-11 years	13-30 years

	Practical Circularity	Collaborative Circularity	Tactical Circularity	Financially-Driven Circularity
Key Insight	Practical interventions address short-term barriers and facilitate immediate progress while creating a foundation for integrating broader strategic changes.	Collaboration and leadership are necessary to bridge resource gaps and build partnerships, especially for smaller public authorities.	Clear and consistent frameworks are critical to align stakeholders, streamline processes, and embed circularity into organizational practices.	Financial strategies create market-driven incentives for circular procurement, emphasizing the economic viability of circular practices.
Institutional Logic Connection	Project Logic: Short-term, task-oriented decision-making for quick implementation.	Community Logic: Emphasizes shared norms, collaboration, and mutual support across sectors.	Asset Management Logic: Focus on long-term reliability and risk aversion through standardized processes.	Market Logic: Driven by profitability and competition, focusing on financial levers to shape behaviour.

Practical Circularity reflects the priorities of project managers and sustainability advisors with varying experience (2–25 years). This perspective emphasizes actionable, hands-on solutions like flexible regulations and improved logistics, underpinned by a project logic that values short-term, task-oriented decision-making. The focus here is to overcome current barriers quickly, with less reliance on complex organizational or financial mechanisms.

Collaborative Circularity prioritizes leadership, collaboration, and shared responsibility, aligning with community logic, which emphasizes shared norms and partnerships across sectors. Driven by sustainability advisors and smaller public authorities, this perspective reflects their reliance on cooperation to pool resources and foster innovation. Participants are highly experienced (18–29 years), suggesting a long-term, relationship-based approach to circular procurement.

Tactical Circularity is shaped by asset, tender, and innovation managers with fewer years of experience (2–11 years). Rooted in asset management logic, it stresses the importance of structured processes and standardization to scale circular practices. This group sees standardized frameworks as key enablers, balancing reliability and flexibility for innovation.

Financially-Driven Circularity emphasizes financial incentives and penalties, aligning with market logic, which prioritizes competition and profitability. This perspective is led by senior professionals in program management and sustainability roles (13–30 years), reflecting their expertise in using financial mechanisms to influence behavior and drive circular procurement at scale.

7.2. Recommendations for practice

To advance the procurement of circular viaducts and bridges, practitioners must shift their focus from knowledge-building to action. The high Mean Z-scores for implementation-focused interventions, such as the program approach and alternative verification methods, demonstrate that these practical, tested solutions are perceived as effective and should be prioritized. Instead of generating more knowledge, practitioners should concentrate on learning by doing. Through implementing these impactful strategies, ensuring progress through tangible results.

Strengthening partnerships is critical, particularly for smaller public authorities like municipalities and provinces. These stakeholders, often grouped under the collaborative perspective, rely on shared resources and connections to overcome their limited capacity compared to larger entities like Rijkswaterstaat. Practitioners should foster partnerships across public authorities, market parties, and

knowledge institutions to pool resources and expertise. Regular dialogue, collaborative platforms, and joint initiatives can help these smaller authorities play an active role in circular procurement.

To support this collaboration, standardizing frameworks should be a priority. Consistent, clear guidelines can simplify the adoption of circular procurement practices for less experienced contracting authorities, ensuring a unified approach across regions. However, these frameworks should allow for enough flexibility to accommodate innovation and the unique needs of individual projects. By bridging the gap between rigid standards and adaptive practices, public authorities can create a balanced environment for scaling circular procurement.

Additionally, practitioners must focus on aligning roles and perspectives within procurement processes to effectively leverage the insights from the distinct perspectives identified in this study. These perspectives—Practical Circularity, Collaborative Circularity, Tactical Circularity, and Financially-Driven Circularity—offer complementary strengths that, if strategically integrated, can enhance circular procurement outcomes. For instance, those aligned with Practical Circularity can drive immediate, action-oriented solutions, ensuring quick wins. Meanwhile, individuals embodying Collaborative Circularity are well-suited to fostering partnerships and inter-organizational coordination. Tactical Circularity advocates can focus on developing and implementing standardized frameworks to provide clarity and consistency, while Financially-Driven Circularity proponents can design and monitor financial incentives and penalties to sustain long-term impact. By creating a strategy that assigns these perspectives to roles where they can be most impactful, practitioners can minimize conflicts and ensure these diverse priorities work in synergy, creating a balanced and effective approach to scaling circular procurement.

In conclusion, the next step in scaling circular procurement is not more knowledge-building, but practitioners should take steps to shift towards actionable strategies, prioritize partnerships, standardize frameworks. By doing so, they can overcome existing barriers and drive meaningful progress in circular procurement practices for bridges and viaducts.

7.3. Recommendations for future research

The results and insights presented in this thesis offer valuable contributions to understanding stakeholder perspectives in circular procurement and identifying important interventions for scaling these practices. However, these findings also highlight areas where further research is needed to deepen our understanding of circular procurement in public infrastructure. Future research could address the following recommendations:

- A larger, more diverse sample that includes stakeholders from various functional roles and levels of experience, particularly those with limited exposure to circularity, would provide a broader range of viewpoints. This would enhance the understanding of circular procurement dynamics across different contexts and reveal how perspectives vary with experience and organizational role.
- Broaden the scope of circular procurement research to explore practices beyond material reuse, such as the incorporation of bio-based materials and other innovative circular approaches. This would offer a fuller picture of the circular procurement landscape and the various methods that can contribute to sustainability.
- Conduct research that follows stakeholder perspectives and procurement practices over an extended period. This would help to understand how priorities evolve and how new policies influence circular procurement in the long run.
- Investigate the specific challenges and opportunities faced by smaller public authorities, such as municipalities and provinces, in implementing circular procurement. Exploring their collaborative efforts and resource limitations could provide insights into how they can better integrate circular practices in partnership with larger entities.

7.4. Personal Reflection

With this master's thesis, I am closing an important chapter of my time in Delft. Circular viaducts and bridges turned out to be an incredibly interesting but also fast-moving and unpredictable topic to work on. Throughout the process, I found myself navigating a constantly evolving field, with new documents and reports being released while I was still working on my thesis. This ongoing influx of information was one of the reasons why I chose to shift the focus of my research from designing a new procurement process to gathering and analyzing insights from key stakeholders about the information that was already available.

What really surprised me during the research was discovering how active the community surrounding circular viaducts and bridges already is. Attending several events showed me just how many people are working on the very topics I was researching, and it was inspiring to see the level of commitment and enthusiasm they have. Changing my research question and method did lead to a slight delay in my timeline, which meant my interviews took place in August—right in the middle of the vacation season. Despite this, I had no trouble arranging fourteen interviews, and I was pleasantly surprised by how eager everyone was to participate. All of the participants were either people I had met at events or professionals my supervisor connected me with, and all were very willing to engage in the study.

The research method I chose, Q-methodology, was something I had only heard about in passing during a lecture, but it turned out to be a great choice. Doing thorough research on the interventions before conducting the interviews gave me a solid understanding of the existing knowledge base. One of the participants from Rijkswaterstaat even commented:

"It's very interesting. I honestly think you were very thorough with the interventions... it would make a nice checklist for us to see if we're covering everything."

The Q-sort interviews themselves were a refreshing change from traditional interviews. Instead of simply answering questions, participants were actively engaged, forced to think deeply about the interventions and rank them based on what they believed would make the most impact. This led to interesting discussions during the post-sort interviews, where we delved into their reasoning for how they ranked the interventions. One participant expressed it nicely:

"It's funny to see what it does to you... you're laying things out, and while I don't necessarily agree with everything, it forces you to put things into perspective. You're also forced to make choices, not about making the right choice, but about the relative importance of each. That's where the conversation starts, and that's interesting."

The data analysis that followed was a new challenge for me, especially connecting the quantitative analysis with the qualitative data from the interviews. It was not something I had done before, but with plenty of reading and a software program that helped guide me through the steps, it was manageable. The real challenge, though, was interpreting the data and linking the results back to the stakeholder insights. With a structured approach, I was able to work through this and produce meaningful results.

This thesis also gave me my first real exposure to professional life, through my involvement with Witteveen+Bos. Since I had not done an internship before and did not have any work experience related to the field, working alongside my supervisors and seeing their day-to-day activities gave me a valuable perspective. Being able to ask questions and occasionally join on real-world projects gave me a much clearer understanding of how theory translates into practice.

In the end, I have learned a lot from this experience. I realized the importance of flexibility in research, especially when the field you're working in is constantly changing. I also gained a deeper appreciation for how crucial collaboration is, both in academia and in industry. Finally, balancing the quantitative and qualitative sides of the research process has been a valuable skill that I will carry forward. This thesis journey has not only expanded my knowledge but also helped me feel more connected to the practical work being done in the field of circular infrastructure. Hopefully this is not the last time I work on circular infrastructure.

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A

Context

This section provides the context of the research, beginning with the overarching goals set by the National Programme Circular Economy 2023-2030 (NPCE) and narrowing down to the specific implementation strategies and the role of the Small Business Innovation Research (SBIR) program in achieving these goals, with a focus on circular viaducts and bridges.

National Programme Circular Economy 2023-30 (NPCE)

As mentioned in the introduction, the Netherlands aims to be fully circular by 2050 (Ministerie van Infrastructuur en Waterstaat, 2016). This program increased support for the circular economy within the country. Subsequently, five transition agendas were developed and translated into concrete actions and projects in the 'Circular Economy Implementation Program 2019-2023'.

The National Program Circular Economy (NPCE) elaborates on this ambitious climate goal. It defines four 'levers' that can be adjusted to make the use of resources more circular, see figure A.1: reduction of resource use, substitution of resources, extension of product lifespan, and high-quality recycling (Ministerie van Infrastructuur en Waterstaat, 2023a).

Figure A.1: Levers for circularity (Ministerie van Infrastructuur en Waterstaat, 2023a)

The NPCE also delves into the objectives concerning circular viaducts and bridges. In this regard, the government aims to achieve a 50% reduction in environmental impact by 2030 compared to 2019 levels. To reach this target, five circularity goals have been specified in the NPCE, specifically for circular bridges and viaducts (Ministerie van Infrastructuur en Waterstaat, 2023a):

1. **Integral Circularity Consideration:** By 2030, all construction and replacement projects will assess circularity to reduce environmental impact (MKI), starting with 'frontrunners' in 2025. This

includes designing all new and replacement bridges and viaducts circularly from 2025, covering all lifecycle phases.

2. **Achieving Technical Lifespan:** From 2030, existing viaducts will achieve their intended technical lifespan. This requires adequate and circular maintenance of current structures, integrating preventive and predictive maintenance into asset management processes.
3. **Aligning Technical and Functional Lifespan:** From 2030, the technical lifespan of new bridges and viaducts will match their functional lifespan. This means new structures must be designed to be adaptive, flexible, and robust to accommodate future functional changes, preventing premature demolition and replacement.
4. **High-Quality Reuse of Elements:** By 2030, high-quality reuse of all components from decommissioned bridges and viaducts will be ensured. At least 80% of non-reusable materials will be recycled at a high-quality level. All concrete bridges and viaducts to be demolished will undergo circular demolition to facilitate this process.
5. **Use of Alternative Materials:** For all new bridges and viaducts, alternative materials (secondary or renewable) will be promoted. For new concrete use, a gradually increasing minimum percentage of secondary materials will be required, with specific targets to be established by 2030.

Circularity in the Construction Industry

The construction sector is an important player in achieving the NPCE's objectives. Bridges and viaducts, as critical civil infrastructure components, are central to this effort. The construction and demolition of such structures involve significant resource use and environmental impact. This makes the development of circular construction techniques and reuse of materials in this sector a top priority.

Innovation in circular procurement and the design of these civil structures—especially bridges and viaducts—can greatly reduce resource consumption and environmental damage. Addressing the lifespan of these assets and finding ways to reuse their materials form core objectives of the NPCE's vision for a circular construction industry.

Implementation of NPCE

To implement the NPCE, the Ministry of Infrastructure and Water Management uses the climate-neutral and circular infrastructure strategy (KCI), which describes five transition pathways. The transition pathway civil structures (transitiepad kunstwerken) focuses on sustainable design, construction, and maintenance of viaducts and bridges, as well as other civil structures such as locks, tunnels, retaining walls (Ministerie van Infrastructuur en Waterstaat, 2020).

In Transitiepad Kunstwerken, the Ministry has heightened their ambitions by setting a fully circular goal for 2030. To achieve this goal, they have outlined three themes and six interventions (Infrastructuur en Waterstaat, 2023), see figure A.2. The SBIR Circular Viaducts, and subsequently this research focuses on existing viaducts and bridges that are decommissioned and new and replacement viaducts and bridges.

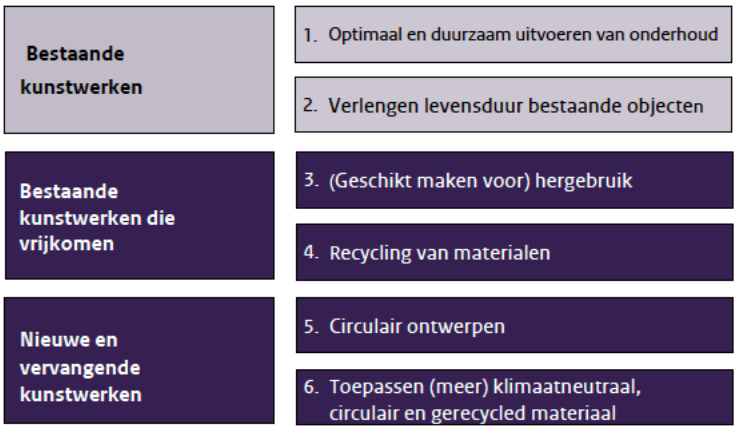

Figure A.2: The three themes within transitiepad kunstwerken, the later two are the focus in this research (Group, 2024)

Small Business Innovation Research (SBIR)

To achieve their objective of becoming completely circular by 2030, as defined in Transitiepad Kunstwerken (Ministerie van Infrastructuur en Waterstaat, 2024), the Rijkswaterstaat will have to focus on innovation across various dimensions, including both product and process innovations. Public procurement plays an important role in fostering innovation by creating demand for novel solutions, yet traditional procurement methods often hinder the adoption of circular economy concepts due to their focus on short-term costs rather than long-term value and sustainability (Insgård, 2023). The European Union, including the Dutch government, has recognized the need of innovation-driven procurement to support the development of innovation, through initiatives like the Small Business Innovation Research (SBIR).

Within the European Union the program for innovation-driven procurement is called 'precommercial procurement' (PCP) (Rigby, 2016). The PCP concept was officially introduced by the European Commission in 2006. One of the main reasons for developing the PCP concept, was to support development of innovation through the public sector. The PCP was designed to overcome a gap between the market and the scientific knowledge, by creating public demand (Delina et al., 2021). The PCP program aligns with existing regulations and adheres to the foundational principles of public procurement, namely open and free competition, transparency, proportionality, and equal treatment (Edquist & Zabala Iturriagagoitia, 2013). In PCP, the public entity does not exclusively hold the outcomes of R&D for its own use (EU, 2008). Instead the intellectual property rights (IPR) are either entirely owned by the supplier or shared with the public agency after negotiations. This arrangement allows both the public bodies and the private sector to jointly bear the risks and rewards of conducting R&D necessary for creating new knowledge. This can lead to the development of innovative solutions that surpass existing ones in the market (EU, 2008). Consequently, this setup encourages both parties to aim for broad market application and adoption of these innovative solutions

Members of the European Union have since adopted their own version of the PCP concept, for example the Small Business Research Initiative (SBRI) in the UK or Small business Innovation Research (SBIR) in the Netherlands (Edquist & Zabala Iturriagagoitia, 2013). In 2004, two years before the European commission officially introduced the PCP concept, the Dutch government applied their SBIR program with the intention of finding innovative solution to societal issues within a short time span (Agency, 2011). The name might suggest that the target group consists of small and medium-sized enterprises, however, any company, regardless of its size, has a chance in tendering procedures (Agency, 2011).

The Dutch government used the US Small Business Innovation Research (SBIR) program as a role model for the Dutch version. The US program was created in 1982, which mostly aimed at stimulating technological innovation, specifically designed for small businesses (Edquist & Zabala Iturriagagoitia, 2013). The Dutch SBIR has a stronger emphasis on societal challenges and commences when a governmental entity identifies a particular challenge or societal issue requiring new, innovative solutions and allocates a budget accordingly (Agency, 2011). Subsequently, the public authority initiates an open

competition within a specified tender period. This competition is framed around a desired outcome or challenge rather than a detailed set of specifications, which is typical in procurement processes. An independent evaluation committee assesses proposals based on four criteria: impact, technological feasibility, economic viability, and budgeted costs (RVO, 2020).

Similar to the approach of the US SBIR, contracts are awarded after a three-phase competition that includes feasibility study, development, and commercialization stages. However, in the Dutch model, the contracting authority subsidizes the first two stages with a fixed-cost research and development contract, leaving the financing of the commercialization phase on the entrepreneur. This implies that the commercialization or scaling up phase does not formally fall under the scope of the Dutch SBIR program (RVO, 2020). The stages of the Dutch SBIR can be found in table A.2(RVO, 2020):

Phase	Description
Phase 1 - Feasibility Stage	The most promising entrepreneurs are awarded contracts, along with financial support, to assess the feasibility of their ideas (on paper). This assessment covers organizational, legal, technical, financial, and commercial aspects. Within the agreed-upon timeframe and budget, these entrepreneurs conduct thorough feasibility studies on their innovations. Entrepreneurs have the option to collaborate with knowledge institutions or other businesses, or to outsource certain aspects of the work. Following advice from the evaluation committee, the contracting authority selects projects to advance to the next phase.
Phase 2 - Development and testing of innovation	All feasible ideas from phase 1 compete again with the same evaluation criteria, plus the economic prospects for phase 2 are given more explicit consideration. Entrepreneurs start a research and development process, delivering the final result for the agreed price and within the timeframe. The contracting authority works with the entrepreneur for the best outcome.
Phase 2a Phase 2b	Developing a prototype. Testing the prototype in practice.
Phase 3 - Up-scaling	Successful innovations from phase 2 prepare for market entry, potentially with financial support from external financiers, ideally identified early in phase 2. The government does not finance this phase but promotes the innovations and monitors progress.

Table A.2: Process stages of Dutch SBIR

SBIR Circular Viaducts

In 2019, Rijkswaterstaat constructed the first circular viaduct in collaboration with contractor 'Van Hattum en Blankevoort' and precast concrete manufacturer 'Consolis Spanbeton', and initiated an open learning environment (Rijkswaterstaat, n.d.). This effort led to the start of the SBIR Circular Viaducts program in 2020, in order to explore the pathway for circular viaducts.

The goal of the SBIR Circular Viaducts was to develop validated solutions for the creation of circular viaducts for (national) roads that Rijkswaterstaat can repeatedly purchase and apply in replacement and new construction projects, but that could also be purchased by other (semi-)public organizations and/or private parties (Rijkswaterstaat, 2024). An additional aim of the SBIR was to broaden the base of providers capable of delivering such circular solutions. This program sought to make the construction and maintenance of viaducts more sustainable, ultimately contributing to the Netherlands' ambitious goals of becoming fully circular by 2050, with Rijkswaterstaat aiming for circularity by 2030.

Rijkswaterstaat challenged entrepreneurs to present innovative solutions for circular viaducts and were amazed by over 32 submissions. These submissions highlighted three distinct circular concepts: Reuse, Modular construction, and Bio-based construction. These submissions were evaluated based

on their impact, feasibility, and economic perspective. In September 2020, the evaluation committee selected the ten most promising project proposals to proceed to the official Phase 1 of the SBIR, which involved conducting a feasibility study. At the end of Phase 1, approximately six months later, the evaluation committee selected three consortia from those ten feasibility studies to proceed with the development of a prototype. The three chosen consortia were ViCi, Closing the Loop, and Combinatie Liggers 2.0. On the next page, their concepts, results, and current status will be discussed.

Consortium 1: ViCi
The ViCi Consortium, consisting of Boskalis Nederland, Integraaljagersm ABT, and Martens beton, introduced an innovative concept centered around modular viaduct construction. The ViCi concept, short for ”viaducts circular”, is a modular arch viaduct. It’s constructed from curved concrete elements that can be easily disassembled and reassembled elsewhere. This circular design requires less material and maintenance, with elements lasting 200 years, offering more than 50% savings in environmental impact and costs. On top of this, their design emphasized the ability to easily dismantle and reuse components, contributing to a circular economy in infrastructure. This approach not only aimed to reduce waste but also to adapt to varying future needs. (ViCi, 2022)

In the second half of 2022, ViCi developed and tested their prototype. The ViCi consortium constructed their prototype near Beuningen, focusing on demonstrating significant circular construction benefits, with a 57% reduction in environmental impact and a 58% decrease in life cycle costs as a result. Furthermore, the prototype was successfully dismantled after the tests were completed, showcasing the modularity of their concept. They successfully concluded phase 2a of the SBIR with this achievement. (ABT, 2022)

The concept was complex, requiring extensive discussions and additional calculations with the bridge team at Rijkswaterstaat. The design demands more space than traditional viaducts, making phase 2b, the search for a suitable location to test the prototype in operational conditions, more challenging. However, at this moment, a potential site has been identified, and the design is being further developed. (Rijkswaterstaat, 2024)

Consortium 2: Closing the Loop
The Closing the Loop consortium, consisting of Nebest, Antea Group, Strukton Civiel, and GBN, introduced an innovative initiative to elevates the reuse of viaducts through the application of circular economy principles. Closing the Loop aims to reuse as many parts of existing structures as possible. The consortium achieves this through collaboration within the supply chain. Within this consortia, five sub-innovations are being developed: a Reusability Scan, Circular Design Concepts, Harvesting from Existing structures, Realization of Circular Structures, and Reuse of Circular civil works. (Nebest, 2021)

At the A76 highway, Closing the Loop accomplished their goal of full circularity, utilizing parts from three other viaducts in a single structure, which includes two types of beams, abutments, piers, and handrails. They have also successfully implemented the reusability scan on various Rijkswaterstaat objects, demonstrating its practical application(Rijkswaterstaat, 2024). The consortium fulfills its mission through five partial innovations, with the Reusability Scan being the first of these innovations (Nebest, 2023).

Consortium 3: Combinatie Liggers 2.0
The Combinatie Liggers 2.0 consortium, led by Royal HaskoningDHV along with partners Vlasman, SGS Intron, Dura Vermeer, and Haitsma, introduces an innovative method for re-purposing concrete prefabricated beams from dismantled viaducts. By extending the lifespan of building materials and significantly, it reduces the environmental footprint and costs associated with new constructions (Vergoossen et al., 2022).

At the heart of Combinatie Liggers 2.0’s concept is the high-quality reuse of precast concrete beams that have outlived their original purpose but remain structurally sound. A feasibility study confirmed these beams could last an additional 200 years, demonstrating the sustainability

benefits of reusing materials over new production (Rijkswaterstaat, 2022).

The consortium showcased this concept by harvesting beams from an A7 viaduct in Groningen, repurposing them for new construction projects. A notable achievement was the reuse of beams in the Hoog Burel viaduct over the A1, launched in January 2023, resulting in a 90% reduction in CO2 emissions and material savings (Rijkswaterstaat, 2024).

Adapting these beams to meet modern standards presented challenges, such as resizing and reinforcing to comply with current regulations. Despite these hurdles, the project successfully illustrated the feasibility and environmental benefits of their circular approach.

Buyer Group Circular Viaduct and Bridges

Buyer Groups are comprised of public sector clients who collaboratively develop a shared market vision and procurement strategy for a specific product or service. This approach provides buyers with support during the procurement process of (circular) products or services (Group, 2024).

In October 2021, Rijkswaterstaat initiated the Buyer Group for Circular Viaducts and Bridges, following up on the Open Learning Environment for Circular Viaducts and Bridges and the SBIR for Circular Viaducts (Group, 2024). The Buyer Group is intended for public organizations that aim to realize a circular viaduct in the coming years. It welcomes participants who are eager to actively contribute to developing a joint market vision and procurement strategy and to implement these in practice (PIANOo, 2021).

The buyer group have collaborated with market parties and experts to make the procurement of circular viaducts and bridges a reality. This effort was guided by three objectives (PIANOo, 2021):

- Sharing knowledge between buyers and suppliers.
- Developing a shared market vision and strategy for circular viaducts and bridges, aimed at enabling the uniform and circular procurement of these structures and informing market parties accordingly.
- Issuing procurement for circular viaducts and bridges to the market within two years, by members of the Buyer Group.

However, despite its ambitions, the Buyer Group has faced challenges in scaling these innovations. Achieving widespread adoption of circular viaducts and bridges remains an ongoing effort.

B

Barriers to Circular Public Procurement

The table presents an overview of the barriers to CPP identified in the literature. With the first column listing the category, the second column providing the barrier and its description, the third column indicating the source, and the fourth column specifying the sector in which each barrier was observed.

Table B.1: Barriers to Circular Public Procurement identified in Literature

Category	Barrier and Description	Sources	Sector
Finance	**1. Higher Costs:** Circular products and services often cost more than traditional options.	Blair and Wrigh (2012), Filho et al. (2019), Marchuk (2020), and Preuss (2009)	Public / Construction
	2. Budget Constraints: Limited budgets restrict the adoption of costlier circular practices.	Chari and Chiriseri (2014) and Lysons and Farrington (2006)	Public
	3. Lack of Incentives: Absence of financial incentives such as tax breaks or subsidies.	Coenen et al. (2022) and Perera et al. (2016)	Infrastructure
	4. Storage and Transport Costs: High costs related to the storage and transport of reusable materials.	Marchuk (2020)	Construction
Knowledge	**1. Lack of Awareness:** Low awareness among decision makers and staff about sustainable practices.	Butler and Keaveney (2014), McMurray et al. (2014), and Testa et al. (2012)	Construction / Public
	2. Lack of Experience: Limited experience with circular practices hinders effective implementation.	Bouwer et al. (2006), Cheng et al. (2018), and Filho et al. (2019)	Public
	3. Unclear Terminology: Inconsistent application and understanding of circular economy terms.	Adams (2021), Chamberlin et al. (2013), and De Jesus and Mendonça (2018)	Building / Public

Category	Barrier and Description	Sources	Sector
	4. Information Exchange: Poor sharing of knowledge across the sector.	Adams (2021) and Tura et al. (2019)	Building / Waste Management
Leadership and Strategy	**1. Lack of Top Management Commitment:** Insufficient support from top management for CPP.	Bloch and Bugge (2013), Cheng et al. (2018), and Roman (2017)	Public
Policy and Regulation	**1. Ineffective Policies:** Policies that do not effectively support the transition to a circular economy.	Adams (2021), De Jesus and Mendonça (2018), and Rizos et al. (2015)	Public / Private
	2. Inflexible Laws: Laws that hinder the reuse of materials due to stringent requirements.	Bloch & Bugge, 2013; Wahlström et al., 2021; Marchuk, 2020	Public / Construction
	3. Regulatory Confusion: Lack of clarity in regulations hampers adoption of CPP practices.	Cheng et al. (2018) and Marchuk (2020)	Public / Construction
Organization	**1. Resource Limitations:** Lack of capacity and resources within organizations to implement CPP.	Bouwer et al. (2006), PRIMES (2016), and Testa et al. (2012)	Public
	2. Risk Averse Culture: Organizational culture that avoids risks, impacting innovation.	Cinar et al. (2019), Kirchherr et al. (2017), and Koch et al. (2006)	Public
	3. Challenges for Smaller Authorities: Smaller entities face greater obstacles due to limited resources.	Michelsen and de Boer (2009) and Testa et al. (2012)	Public
	4. Unsolicited Proposals: Difficulties in managing proposals that are not explicitly requested.	Coenen et al. (2022) and Perera et al. (2016)	Infrastructure
Implementation and Scaling	**1. Material Management:** Challenges related to the management of storage and quality assurance of reuse materials.	Havinga et al. (2023)	Construction
	2. Project-Based Approach: The custom-made, non-standardized project approach limits the scalability and efficiency of CPP.	Havinga et al. (2023)	Construction

C

Empirical Interventions

Table C.1: Collected interventions through empirical documents

No.	Category	Intervention description	Extract from source	Source and Source description
1	Finance	Make the use of secondary products more attractive.	”Reward the use of secondary products and make it attractive, for example, by not charging VAT again.”	(Buyer Group, 2024) Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
2	Finance	Introduce financial incentives for circular performance.	”A financial incentive in the contract where the contractor is rewarded for achieving higher circular performance.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
3	Finance	Make budget decisions based on Total Cost of Ownership (TCO).	”An option is to make budget decisions based on Total Cost of Ownership (TCO) or life cycle costs (LCC) rather than investment costs. Such an integral budget consideration allows for more circular solutions.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
4	Finance	Sustainability budget.	”If a sustainable idea can be applied in a project, a sustainability budget can be requested.”	(SROKS, 2024) Guideline for Climate-Neutral and Circular Infrastructure
5	Knowledge	Improve standard texts for the sustainable Project Assignment Form (POF)/scope form and (Client requirements specifications) KES and implement them widely in the organization.	”Improving standard texts for sustainable POF/scope form and KES, making it easier to incorporate sustainability effectively into POF/scope form and KES.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS

No.	Category	Intervention description	Extract from source	Source and Source description
6	Knowledge	Map successful and less successful sustainability interventions in different regions.	”Providing insights into which sustainability interventions are being and have been implemented in different regions so that knowledge can be shared between regions. This allows interventions to be applied more quickly and avoids reinventing the wheel.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
7	Knowledge	Establish an implementation team.	”Accelerating the realization of pre-production-ready measures and thus giving substance to the allocated 2% budgets.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
8	Knowledge	Train the trainer for sustainability advisors / sustainability coordinators.	”In consultation with a representation of supporters, a training program is developed (if necessary, supported by external parties) to contribute to further professionalization.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
9	Knowledge	Knowledge and inspiration carousel from meetings.	”Show ’that and how it can be done’ by sharing the substantive, organizational, and human insights and outcomes from projects where KCI has been successfully implemented.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
10	Knowledge	Strengthen (digital) knowledge exchange, visibility of available information, and sharing of best practices.	”Better showcase and make available the existing knowledge, insights, and best practices on sustainability.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
11	Knowledge	Structural exchange of knowledge between clients and market parties.	”Organize a structural exchange of knowledge between clients and involved market parties.”	(Buyer Group, 2024) Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges

No.	Category	Intervention description	Extract from source	Source and Source description
12	Knowledge	Develop and collect knowledge about circularity and introduce it early in procurement processes.	”Develop and collect knowledge about circularity and introduce it early in procurement processes. This is important because circular construction is a relatively new field that continues to evolve. Ensure that knowledge is documented so that it remains embedded in the organization.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
13	Leadership and Strategy	Portfolio/program approach.	”Through long-term contracts with multiple projects in one contract, the market gains visibility on what will be happening in the coming years, allowing market parties to gain the necessary knowledge and make investments.”	(Buyer Group, 2024) Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
14	Leadership and Strategy	Standardization of procurement strategy.	”Providing insight into how the involved clients can implement sustainable procurement of bridges and viaducts, depending on their level of experience (the so-called procurement level).”	(Buyer Group, 2024) Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
15	Leadership and Strategy	Determine responsible person for circular procurement policy.	”Determine who is responsible for the implementation of the circular procurement policy. Preferably, this is the same person responsible for the general procurement policy.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
16	Leadership and Strategy	Validate ambition with market research and market consultation.	”Market research is intended to validate and refine the circular needs, ambitions, potential specifications, and conflicting interests (client/market parties).”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
17	Policy and Regulation	Reevaluate frameworks.	”Adjust frameworks so that more sustainable concepts can be applied.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS

No.	Category	Intervention description	Extract from source	Source and Source description
18	Policy and regulation	Develop and collect knowledge about circularity and introduce it early in procurement processes.	”Embed circular procurement in the annual accountability cycle. Include circularity in existing budgets, annual plans, and annual reports; a new reporting line is not necessary. Ensure that the annual report provides insight into the degree of circularity of procurements.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
19	Policy and regulation	Allow space for alternative verification methods.	”It is important to properly verify the offered values but also to remain flexible. The values of innovations or innovations may not always be demonstrable via standard verification methods. Therefore, allow space for alternative verification methods.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
20	Policy and regulation	Standard sustainability requirements.	”Rijkswaterstaat fulfills the national goal of 100% sustainable procurement through the MVI criteria. These MVI criteria include minimum requirements for energy and material use and must be included in all contracts.”	(SROKS, 2024) Guideline for Climate-Neutral and Circular Infrastructure
21	Organization	System in the room at project level.	”Literally bringing together in one room the staff responsible for drafting the POF, sustainability advisors, PPO staff, and potentially additional experts to discuss the opportunities and implications of sustainability measures on projects across the entire chain. The aim is to surface and address obstacles, leading to quicker implementation.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
22	Organization	Involve regional sustainability advisors and sustainability advisors with colleagues in the procurement process.	”The idea behind this measure is to have sustainability advisors/coordinators work alongside staff responsible for implementing sustainability in the operation or those who, due to their roles, deal with the consequences of sustainability measures.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS

No.	Category	Intervention description	Extract from source	Source and Source description
23	Organization	Introduction of early-phase advisors.	”Increasing the capacity of sustainability advisors in the regions, specifically focused on the first/early phases of projects.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
24	Organization	Buddy system for role groups.	”The aim is to set up pairs who provide practical support to each other when needed. Initially, this is envisioned for roles with similar or adjacent responsibilities within the organization. This way, people understand what the other is working on and can genuinely support each other. Support from the buddy can be content-related or skill-related.”	(Rebel Group, 2023), Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
25	Organization	Look beyond project boundaries with other clients and the market.	”Work together with other clients and the market to look beyond project boundaries and increase the opportunities for matching.”	(Buyer Group, 2024) Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
26	Organization	Ensure support for circular procurement throughout the organization.	”There must be support for and involvement in circularity throughout the organization, not just at the management level and in the procurement department.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
27	Organization	Long-term collaborations and long-term framework agreements.	”Long-term collaborations and long-term framework agreements: these can further develop circular solutions. Circular KPIs can be refined during the term of the agreement.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector
28	Organization	Collaborative framework agreement for engineering services (SROK ID).	”The collaborative framework agreements for engineering and consultancy services contribute to an efficient and effective way of bringing services to market and realizing them. Additionally, with the SROKs, we invest in a sustainable relationship between the market and Rijkswaterstaat.”	(SROKS, 2024) Guideline for Climate-Neutral and Circular Infrastructure

No.	Category	Intervention description	Extract from source	Source and Source description
29	Implementation	Organize storage of materials at a regional or national level.	”Organize storage of materials and objects at a regional or national level.”	(Buyer Group, 2024) Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
30	Implementation	Use Life Cycle Analysis (LCA) and Environmental Cost Indicator (MKI).	”Environmental impacts can be expressed using the Environmental Cost Indicator (MKI); a monetary outcome of a Life Cycle Analysis (LCA). ”MKI encourages circular solutions.””	(Pianoo, 2019) Procuring with MKI. Expertise Center for Procurement
31	Implementation	Pay attention to the transition from project organization to asset management organization.	”Pay attention to the transition of a project from the project organization to the asset management organization. Consider how an asset manager or operator should handle the circular construction.”	(Platform CB’23, 2021) Guideline Circular Procurement. Specific for both construction and infrastructure sector

D

Combined Interventions

Table D.1: Combined Interventions for Circular Economy and Procurement

No.	Category	Intervention description	Extract from source	Identified through
1	Finance	Establish financial implications	”Organizations should establish the financial implications (positive or negative) of implementing the principles of the circular economy. Existing legal and financial systems that support traditional forms of business might not necessarily be helpful or clear.”	Theoretical (BSI, 2017) - Framework, private sector
2	Finance	Make the use of secondary products more attractive.	”Reward the use of secondary products and make it attractive, for example, by not charging VAT again.”	Empirical (Buyer Group, 2024) - Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
3	Finance	Considering Life-Cycle Costing (LCC)	”This enables public authorities to achieve cost savings and efficiency gains, leading to a ‘win-win’ situation: a greener product or service can also turn out to be cheaper if the overall cost across the whole life cycle is considered”	Theoretical (De Giacomo et al., 2019) - Paper on Green Public Procurement and Life Cycle Costing, not sector specific
4	Finance	Introduce financial incentives for circular performance.	”A financial incentive in the contract where the contractor is rewarded for achieving higher circular performance.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector

No.	Category	Intervention description	Extract from source	Identified through
5	Finance	Make budget decisions based on Total Cost of Ownership (TCO).	”An option is to make budget decisions based on Total Cost of Ownership (TCO) or life cycle costs (LCC) rather than investment costs. Such an integral budget consideration allows for more circular solutions.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector
6	Finance	Invest in organizational and operational change	”When used for circularity, available resources are often allocated to specific pilot projects and technologies, while for making steps in circularity, resources need to be allocated to structural organizational and operational change.”	Theoretical (Coenen et al., 2022) - Article on transition barriers to a circular infrastructure sector
7	Finance	Sustainability budget.	”If a sustainable idea can be applied in a project, a sustainability budget can be requested.”	Empirical (SROKS, 2024) - Guideline for Climate-Neutral and Circular Infrastructure
8	Knowledge	Incorporate CE training into the professional license requirements	”Organizations should incorporate CE training into the requirements of purchasers, engineers, and contractors. Such requirements will encourage seeking knowledge and skills about circularity.”	Theoretical (Cruz Rios et al., 2021) - Paper on barriers and enablers towards CE in construction, in the US
9	Knowledge	Improve standard texts for the sustainable Project Assignment Form (POF)/scope form and (Client requirements specifications) KES and implement them widely in the organization.	”Improving standard texts for sustainable POF/scope form and KES, making it easier to incorporate sustainability effectively into POF/scope form and KES.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
10	Knowledge	Map successful and less successful sustainability interventions in different regions.	”Providing insights into which sustainability interventions are being and have been implemented in different regions so that knowledge can be shared between regions. This allows interventions to be applied more quickly and avoids reinventing the wheel.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS

No.	Category	Intervention description	Extract from source	Identified through
11	Knowledge	Establish an implementation team.	”Accelerating the realization of pre-production-ready measures and thus giving substance to the allocated 2% budgets.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
12	Knowledge	Train employees to learn benefits and practices for CE implementation	”Skills improvement training of employees can help to learn benefits, tools, and strategies to apply a CE.”	Theoretical (Qazi & Appolloni, 2022) - Review article on barriers and enablers towards CP
13	Knowledge	Establish Best Practices	”Empirical studies should be conducted based on real-life examples. It will help all stakeholders, especially government and practitioners, to follow best practices. For example, real success and failure stories in implementing circular procurement.”	Theoretical (Qazi & Appolloni, 2022) - Review article on barriers and enablers towards CP
14	Knowledge	Train the trainer for sustainability advisors / sustainability coordinators.	”In consultation with a representation of supporters, a training program is developed (if necessary, supported by external parties) to contribute to further professionalization.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
15	Knowledge	Knowledge and inspiration carousel from meetings.	”Show ’that and how it can be done’ by sharing the substantive, organizational, and human insights and outcomes from projects where KCI has been successfully implemented.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
16	Knowledge	Strengthen (digital) knowledge exchange, visibility of available information, and sharing of best practices.	”Better showcase and make available the existing knowledge, insights, and best practices on sustainability.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS

No.	Category	Intervention description	Extract from source	Identified through
17	Knowledge	Structural exchange of knowledge between clients and market parties.	”Organize a structural exchange of knowledge between clients and involved market parties.”	Empirical (Buyer Group, 2024) - Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
18	Knowledge	Develop and collect knowledge about circularity and introduce it early in procurement processes.	”Develop and collect knowledge about circularity and introduce it early in procurement processes. This is important because circular construction is a relatively new field that continues to evolve. Ensure that knowledge is documented so that it remains embedded in the organization.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector
19	Knowledge	Increase organizational learning capability	”Providing a learning environment supports the procurement departments in acquiring new knowledge and skills for CPP, which involves pilot projects used to experiment with external actors and the involvement of suppliers in new innovative ways of achieving circular solutions.”	Theoretical (Kristensen et al., 2021) - Article on CPP practices in the public sector in Denmark
20	Leadership and Strategy	Top level management support	”The most frequently highlighted stimulant of SP practices were support for SP among an organisation’s leadership, and the implementation of concrete strategies and plans within which SP goals were articulated and enshrined.”	Theoretical (Brammer and Walker, 2011) - Article on sustainable procurement in the public sector
21	Leadership and Strategy	Clear strategy	”A clear strategy and commitment to policy is important towards circular public procurement.”	Theoretical (Leire and Mont, 2010) - Paper on Socially Responsible Purchasing in the public sector
22	Leadership and Strategy	Portfolio/program approach.	”Through long-term contracts with multiple projects in one contract, the market gains visibility on what will be happening in the coming years, allowing market parties to gain the necessary knowledge and make investments.”	Empirical (Buyer Group, 2024) - Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
23	Leadership and Strategy	Standardization of procurement strategy.	”Providing insight into how the involved clients can implement sustainable procurement of bridges and viaducts, depending on their level of experience (the so-called procurement level).”	Empirical (Buyer Group, 2024) - Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges

No.	Category	Intervention description	Extract from source	Identified through
24	Leadership and Strategy	Determine responsible person for circular procurement policy.	”Determine who is responsible for the implementation of the circular procurement policy. Preferably, this is the same person responsible for the general procurement policy.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector
25	Leadership and Strategy	Validate ambition with market research and market consultation.	”Market research is intended to validate and refine the circular needs, ambitions, potential specifications, and conflicting interests (client/market parties).”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector
26	Policy and Regulation	Direct support	”The results of the questionnaires were similar to those identified in the literature review with regulations and legislation set by the EU coming out on top as the key driver of GPP.”	Theoretical (Butler and Keaveney, 2014) - Paper on barriers and drivers of GPP in the construction industry
27	Policy and Regulation	Indirect support	”The analysis shows that indirect support through European and national soft regulation and policy advice is imperative for “greening” procurement.”	Theoretical (Hall et al., 2015) - Paper on the challenges of green procurement at the local level
28	Policy and Regulation	Reevaluate frameworks.	”Adjust frameworks so that more sustainable concepts can be applied.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
29	Policy and Regulation	Develop and collect knowledge about circularity and introduce it early in procurement processes.	”Embed circular procurement in the annual accountability cycle. Include circularity in existing budgets, annual plans, and annual reports; a new reporting line is not necessary. Ensure that the annual report provides insight into the degree of circularity of procurements.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector
30	Policy and Regulation	Allow space for alternative verification methods.	”It is important to properly verify the offered values but also to remain flexible. The values of innovations or innovations may not always be demonstrable via standard verification methods. Therefore, allow space for alternative verification methods.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector

No.	Category	Intervention description	Extract from source	Identified through
31	Policy and Regulation	Standard sustainability requirements.	”Rijkswaterstaat fulfills the national goal of 100% sustainable procurement through the MVI criteria. These MVI criteria include minimum requirements for energy and material use and must be included in all contracts.”	Empirical (SROKS, 2024) - Guideline for Climate-Neutral and Circular Infrastructure
32	Organization	Implement change management	”Agree and implement a change management system to enable the organization to implement and sustain the planned change and ensure the prevailing culture is supportive of a move towards a more circular and sustainable mode of operation.”	Theoretical (BSI, 2017) - Framework, private sector
33	Organization	System in the room at project level.	”Literally bringing together in one room the staff responsible for drafting the POF, sustainability advisors, PPO staff, and potentially additional experts to discuss the opportunities and implications of sustainability measures on projects across the entire chain. The aim is to surface and address obstacles, leading to quicker implementation.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
34	Organization	Involve regional sustainability advisors and sustainability advisors with colleagues in the procurement process.	”The idea behind this measure is to have sustainability advisors/coordinators work alongside staff responsible for implementing sustainability in the operation or those who, due to their roles, deal with the consequences of sustainability measures.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
35	Organization	Introduction of early-phase advisors.	”Increasing the capacity of sustainability advisors in the regions, specifically focused on the first/early phases of projects.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS

No.	Category	Intervention description	Extract from source	Identified through
36	Organization	Buddy system for role groups.	”The aim is to set up pairs who provide practical support to each other when needed. Initially, this is envisioned for roles with similar or adjacent responsibilities within the organization. This way, people understand what the other is working on and can genuinely support each other. Support from the buddy can be content-related or skill-related.”	Empirical (Rebel Group, 2023) - Action Plan for Climate-Neutral and Circular Working: Interventions to Help Initiate Change. Specific to the infrastructure sector. Not specific to procurement. Written on behalf of RWS
37	Organization	Inter-departmental coordination	”Inter-departmental coordination and commitment can enhance the use of recycled, remanufactured, and repaired material. The procurement team alone cannot apply circularity.”	Theoretical (Qazi & Appolloni, 2022) - Review article on barriers and enablers towards CP
38	Organization	Inter-organizational coordination	”Collaboration provided strategic bridges enabling the exchange of knowledge between organizations, towards solving problems that no party could address unilaterally.”	Theoretical (Rainville, 2021) - Article on stimulating CE through PP
39	Organization	Look beyond project boundaries with other clients and the market.	”Work together with other clients and the market to look beyond project boundaries and increase the opportunities for matching.”	Empirical (Buyer Group, 2024) - Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
40	Organization	Ensure support for circular procurement throughout the organization.	”There must be support for and involvement in circularity throughout the organization, not just at the management level and in the procurement department.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector
41	Organization	Long-term collaborations and long-term framework agreements.	”Long-term collaborations and long-term framework agreements: these can further develop circular solutions. Circular KPIs can be refined during the term of the agreement.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector
42	Organization	Collaborative framework agreement for engineering services (SROK ID).	”The collaborative framework agreements for engineering and consultancy services contribute to an efficient and effective way of bringing services to market and realizing them. Additionally, with the SROKs, we invest in a sustainable relationship between the market and Rijkswaterstaat.”	Empirical (SROKS, 2024) - Guideline for Climate-Neutral and Circular Infrastructure

No.	Category	Intervention description	Extract from source	Identified through
43	Implementation	Pilot projects	”The first project was the hardest to initiate and complete. However, following these initial experiences and learning, the municipalities can more easily engage in new CPP projects. Using pilot projects to gain experiences with CPP can drive the further uptake of CPP, as the staff involved gain new knowledge and learning through their experiences with CPP.”	Theoretical (Kristensen et al., 2021) - Article on CPP practices in the public sector in Denmark
44	Implementation	Organize storage of materials at a regional or national level.	”Organize storage of materials and objects at a regional or national level.”	Empirical (Buyer Group, 2024) - Market Vision and Procurement Strategy for Circular Viaducts and Bridges. Specific to procurement of circular viaducts and bridges
45	Implementation	Use Life Cycle Analysis (LCA) and Environmental Cost Indicator (MKI).	”Environmental impacts can be expressed using the Environmental Cost Indicator (MKI); a monetary outcome of a Life Cycle Analysis (LCA). ”MKI encourages circular solutions.””	Empirical (Pianoo, 2019) - Procuring with MKI. Expertise Center for Procurement
46	Implementation	Pay attention to the transition from project organization to asset management organization.	”Pay attention to the transition of a project from the project organization to the asset management organization. Consider how an asset manager or operator should handle the circular construction.”	Empirical (Platform CB’23, 2021) - Guideline Circular Procurement. Specific for both construction and infrastructure sector
47	Implementation	Product-based approach	”Collaboration in the construction industry is through the traditional project-based management, which hampers innovation scalability, change and growth of the sector... there is a positive connection between a construction ecosystem implementing a product-based approach and the extent of partner alignment being performed by the lead firms as well as a stronger iterative use of orchestration mechanisms to achieve partner alignment.”	Theoretical (Havinga et al., 2023) - The transition toward circular construction ecosystems, not specific to procurement

E

Q-set development

Table E.1: Complete list of interventions with expert feedback and results

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
1	Finance	Establish financial implications	”Organizations should establish the financial implications (positive or negative) of implementing the principles of the circular economy. Existing legal and financial systems that support traditional forms of business might not necessarily be helpful or clear.”	Theoretical approach	Circular design is usually more expensive. Therefore, it is important to consider aspects such as economic value retention, which are not typically included in a cost analysis.	Included in Q-set
2	Finance	Make the use of secondary products more attractive.	”Reward the use of secondary products and make it attractive, for example, by not charging VAT again.”	Empirical approach	Important, similar to 3	Combined with intervention 3

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
3	Finance	Introduce financial incentives for circular performance.	”A financial incentive in the contract where the contractor is rewarded for achieving higher circular performance.”	Empirical approach	It is a very clear intervention. When looking purely at costs, circularity is often perceived negatively.	Included in Q-set
4	Finance	Make budget decisions based on Total Cost of Ownership (TCO).	”An option is to make budget decisions based on Total Cost of Ownership (TCO) or life cycle costs (LCC) rather than investment costs. Such an integral budget consideration allows for more circular solutions.”	Theoretical and Empirical approach	A method to establish financial implications as mentioned at 1	Combined with intervention 1
5	Finance	Invest in organizational and operational change	”When used for circularity, available resources are often allocated to specific pilot projects and technologies, while for making steps in circularity, resources need to be allocated to structural organizational and operational change.”	Theoretical approach	This relates to organization issues, highlighting the need for investment to drive change. It is a very recognizable challenge.	Combined with intervention 35
6	Finance	Sustainability budget	”If a sustainable idea can be applied in a project, a sustainability budget can be requested.”	Empirical approach	Then you are still thinking on a small pilot scale, whereas it needs to become the standard practice—business as usual.	Not included in Q-set
7	Finance	Financial disadvantages for non-circular practices	-	Expert interview	Drive organizations to adopt circular approaches by making unsustainable practices more costly. This aligns economic incentives with sustainability goals, encouraging a shift toward circularity.	Included in Q-set

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
8	Knowledge	Incorporate CE training into the professional license requirements	”Organizations should incorporate CE training into the requirements of purchasers, engineers, and contractors. Such requirements will encourage seeking knowledge and skills about circularity.”	Theoretical approach	Nowadays, almost all educational programs include some aspect of circularity in their curriculum.	Not included in Q-set
9	Knowledge	Improve standard texts for the sustainable Project Assignment Form (POF)/scope form and (Client requirements specifications) KES and implement them widely in the organization.	”Improving standard texts for sustainable POF/scope form and KES, making it easier to incorporate sustainability effectively into POF/scope form and KES.”	Empirical approach	This is already largely being done as part of regulatory adjustments.	Combined with intervention 31
10	Knowledge	Map successful and less successful sustainability interventions in different regions.	”Providing insights into which sustainability interventions are being and have been implemented in different regions so that knowledge can be shared between regions. This allows interventions to be applied more quickly and avoids reinventing the wheel.”	Empirical approach	Similar to best practices.	Combined with intervention 13
11	Knowledge	Establish an implementation team.	”Accelerating the realization of pre-production-ready measures and thus giving substance to the allocated 2% budgets.”	Empirical approach	Focusing so specifically on a legal basis for deploying an implementation team can be quite challenging to execute at the provincial and municipal levels.	Not included in Q-set

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
12	Knowledge	Train employees to learn benefits and practices for CE implementation	”Skills improvement training of employees can help to learn benefits, tools, and strategies to apply a CE.”	Theoretical approach	Engineering and asset roles often show resistance; however, having more foundational knowledge about circularity could help in reducing this resistance.	Included in Q-set
13	Knowledge	Establish and communicate best practices	”Empirical studies should be conducted based on real-life examples. It will help all stakeholders, especially government and practitioners, to follow best practices. For example, real success and failure stories in implementing circular procurement.”	Theoretical approach	Greatly important. Especially the communication part within an organization.	Included in Q-set
14	Knowledge	Train the trainer for sustainability advisors / sustainability coordinators.	”In consultation with a representation of supporters, a training program is developed (if necessary, supported by external parties) to contribute to further professionalization.”	Empirical approach	Similar to train employees.	Combined with intervention 12
15	Knowledge	Knowledge and inspiration carousel from meetings.	”Show ’that and how it can be done’ by sharing the substantive, organizational, and human insights and outcomes from projects where KCI has been successfully implemented.”	Empirical approach	There is no need for more varied events; instead, a complete gathering of all parties is important, with a focus on deeper engagement and understanding.	Included in Q-set, Altered to focus enhancing these events
16	Knowledge	Strengthen (digital) knowledge exchange, visibility of available information, and sharing of best practices.	”Better showcase and make available the existing knowledge, insights, and best practices on sustainability.”	Empirical approach	An online platform, such as the one provided by CROW, can be very useful for disseminating information.	Included in Q-set

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
17	Knowledge	Structural exchange of knowledge between clients and market parties.	”Organize a structural exchange of knowledge between clients and involved market parties.”	Empirical approach	Similar to other knowledge and collaboration interventions.	Not included in Q-set
18	Knowledge	Develop and collect knowledge about circularity and introduce it early in procurement processes.	”Develop and collect knowledge about circularity and introduce it early in procurement processes. This is important because circular construction is a relatively new field that continues to evolve. Ensure that knowledge is documented so that it remains embedded in the organization.”	Empirical approach	Similar to involving early-phase advisors, who bring expertise on circularity into the procurement process early on, guiding sustainable choices from the beginning.	Combined with intervention 38
19	Knowledge	Increase organizational learning capability	”Providing a learning environment supports the procurement departments in acquiring new knowledge and skills for CPP, which involves pilot projects used to experiment with external actors and the involvement of suppliers in new innovative ways of achieving circular solutions.”	Theoretical approach	An overarching intervention can be incorporated into transition management.	Combined with intervention 35
20	Knowledge	Develop and disseminate consistent terminology.	-	Expert interview	Developing and disseminating consistent terminology ensures clarity and understanding across all stakeholders. It helps align efforts and communication, fostering better collaboration toward shared goals.	Included in Q-set
21	Knowledge	International knowledge sharing	-	Expert interview	Promoting the exchange of knowledge and best practices on an international scale enhances innovation and accelerates the adoption of circular strategies.	Included in Q-set

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
22	Leadership and Strategy	Leading by example	-	Expert interview	Demonstrating successful circular practices sets a standard for others to follow, inspiring organizations and stakeholders to adopt similar approaches and drive widespread change.	Included in Q-set
23	Leadership and Strategy	Top level management support	”The most frequently highlighted stimulant of SP practices were support for SP among an organisation’s leadership, and the implementation of concrete strategies and plans within which SP goals were articulated and enshrined.”	Theoretical approach	There is top management support for goals like becoming fully circular by 2030 or 2050, but there is a significant mismatch between these policy-level objectives and their implementation.	Not included in Q-set
24	Leadership and Strategy	Clear strategy	”A clear strategy and commitment to policy is important towards circular public procurement.”	Theoretical approach	Too broad, and is more focused on policy.	Not included in Q-set
25	Leadership and Strategy	Portfolio/program approach.	”Through long-term contracts with multiple projects in one contract, the market gains visibility on what will be happening in the coming years, allowing market parties to gain the necessary knowledge and make investments.”	Empirical approach	Highly recognizable. Market players value a long-term perspective and clear consistency, as it allows them to invest with confidence. Their needs are actually quite straightforward.	Included in Q-set, category changed to implementation
26	Leadership and Strategy	Standardization of procurement strategy.	”Providing insight into how the involved clients can implement sustainable procurement of bridges and viaducts, depending on their level of experience (the so-called procurement level).”	Empirical approach	An important intervention, has been initiated by the Buyer Group, and public clients are already using it.	Included in Q-set

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
27	Leadership and Strategy	(Determine responsible person for circular procurement policy).	”Determine who is responsible for the implementation of the circular procurement policy. Preferably, this is the same person responsible for the general procurement policy.”	Empirical approach	This also makes sense. Essentially, you’re saying it needs to be an integral part of the procurement policy.	Included in Q-set
28	Leadership and Strategy	Validate ambition with market research and market consultation.	”Market research is intended to validate and refine the circular needs, ambitions, potential specifications, and conflicting interests (client/market parties).”	Empirical approach	Improving collaboration with the market is a key aspect.	Included in Q-set, Altered to improve collaboration with market
29	Policy and Regulation	Direct support	”The results of the questionnaires were similar to those identified in the literature review with regulations and legislation set by the EU coming out on top as the key driver of GPP.”	Theoretical approach	A bit too broad, has connections financial incentives.	Indirectly included in intervention 3
30	Policy and Regulation	Indirect support	”The analysis shows that indirect support through European and national soft regulation and policy advice is imperative for “greening” procurement.”	Theoretical approach	A bit too broad, has connections reevaluating frameworks.	Indirectly included in intervention 31
31	Policy and Regulation	Reevaluate frameworks.	”Adjust frameworks so that more sustainable concepts can be applied.”	Empirical approach	Creating space for reevaluating frameworks is definitely beneficial. There are examples where projects by RWS were not permitted under their own guidelines.	Included in Q-set

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
32	Policy and Regulation	Incorporate circular procurement into the annual accountability cycle.	”Embed circular procurement in the annual accountability cycle. Include circularity in existing budgets, annual plans, and annual reports; a new reporting line is not necessary. Ensure that the annual report provides insight into the degree of circularity of procurements.”	Empirical approach	The importance of re-evaluating and adjusting the ongoing process.	Included in Q-set, as monitoring progress
33	Policy and Regulation	Allow space for alternative verification methods.	”It is important to properly verify the offered values but also to remain flexible. The values of innovations or innovations may not always be demonstrable via standard verification methods. Therefore, allow space for alternative verification methods.”	Empirical approach	If you measure in one specific way, you may not fully appreciate certain innovations that, through a different approach, also contribute to circularity. Therefore, it’s important to consider using an alternative verification method.	Included in Q-set
34	Policy and Regulation	Standard sustainability requirements.	”Rijkswaterstaat fulfills the national goal of 100% sustainable procurement through the MVI criteria. These MVI criteria include minimum requirements for energy and material use and must be included in all contracts.”	Empirical approach	They already have some, like the KCI minimum requirements.	Not included in Q-set
35	Organization	Implement change management	”Agree and implement a change management system to enable the organization to implement and sustain the planned change and ensure the prevailing culture is supportive of a move towards a more circular and sustainable mode of operation.”	Theoretical approach	I think it’s a good idea to involve the entire organization in all aspects of circularity, like in transition management.	Included in Q-set, rephrased to transition management

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
36	Organization	System in the room at project level.	”Literally bringing together in one room the staff responsible for drafting the POF, sustainability advisors, PPO staff, and potentially additional experts to discuss the opportunities and implications of sustainability measures on projects across the entire chain. The aim is to surface and address obstacles, leading to quicker implementation.”	Empirical approach	A lot has already been achieved, creating opportunities for everyone to come together has proven effective.	Indirectly included in intervention 38
37	Organization	Involve regional sustainability advisors and sustainability advisors with colleagues in the procurement process.	”The idea behind this measure is to have sustainability advisors/coordinators work alongside staff responsible for implementing sustainability in the operation or those who, due to their roles, deal with the consequences of sustainability measures.”	Empirical approach	This is a bit of an obvious point.	Indirectly included in intervention 38
38	Organization	Introduction of early-phase advisors.	”Increasing the capacity of sustainability advisors in the regions, specifically focused on the first/early phases of projects.”	Empirical approach	You can maximize the impact on circularity by focusing on it early in the project. As shown in an influence/effort diagram.	Included in Q-set
39	Organization	Buddy system for role groups.	”The aim is to set up pairs who provide practical support to each other when needed. Initially, this is envisioned for roles with similar or adjacent responsibilities within the organization. This way, people understand what the other is working on and can genuinely support each other. Support from the buddy can be content-related or skill-related.”	Indirectly included in intervention 35	Quite general—if you want to achieve something successfully within an organization and ensure people work well together.	Not included in Q-set

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
40	Organization	Inter-departmental coordination	”Inter-departmental coordination and commitment can enhance the use of recycled, remanufactured, and repaired material. The procurement team alone cannot apply circularity.”	Theoretical approach	A large part of circularity naturally falls under asset management. Asset management focuses on maintaining what is already in place, so I believe that the need for coordination will continue to grow.	Included in Q-set
41	Organization	Inter-organizational coordination	”Collaboration provided strategic bridges enabling the exchange of knowledge between organizations, towards solving problems that no party could address unilaterally.”	Theoretical approach	Similar to intervention 42.	Indirectly included in intervention 42
42	Organization	Look beyond project boundaries with other clients and the market.	”Work together with other clients and the market to look beyond project boundaries and increase the opportunities for matching.”	Empirical approach	Greatly important, especially for matching second-hand materials.	Included in Q-set
43	Organization	Ensure support for circular procurement throughout the organization.	”There must be support for and involvement in circularity throughout the organization, not just at the management level and in the procurement department.”	Empirical approach	Similar to intervention 35.	Combined with intervention 35
44	Organization	Long-term collaborations and long-term framework agreements.	”Long-term collaborations and long-term framework agreements: these can further develop circular solutions. Circular KPIs can be refined during the term of the agreement.”	Empirical approach	Greatly important, similar to intervention 50.	Combined with intervention 50

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
45	Organization	Collaborative framework agreement for engineering services (SROK ID).	”The collaborative framework agreements for engineering and consultancy services contribute to an efficient and effective way of bringing services to market and realizing them. Additionally, with the SROKs, we invest in a sustainable relationship between the market and Rijkswaterstaat.”	Empirical approach	Collaboration agreements can be less effective due to the rapid pace of developments.	Not included in Q-set
46	Implementation	Pilot projects	”The first project was the hardest to initiate and complete. However, following these initial experiences and learning, the municipalities can more easily engage in new CPP projects. Using pilot projects to gain experiences with CPP can drive the further uptake of CPP, as the staff involved gain new knowledge and learning through their experiences with CPP.”	Theoretical approach	Pilot projects are done frequently, but the focus should indeed be on scaling them up.	Included in Q-set, focus on up-scaling
47	Implementation	Organize storage of materials at a regional or national level.	”Organize storage of materials and objects at a regional or national level.”	Empirical approach	This is a crucial issue, particularly regarding whether the initiative should come from the client or the market.	Included in Q-set
48	Implementation	Use Life Cycle Analysis (LCA) and Environmental Cost Indicator (MKI).	”Environmental impacts can be expressed using the Environmental Cost Indicator (MKI); a monetary outcome of a Life Cycle Analysis (LCA). MKI encourages circular solutions.”	Empirical approach	In the current MKI, aspects like disassembly and standardization are not adequately valued, so the focus should be on enhancing the MKI to include these elements.	Included in Q-set, focus enhancing MKI

No.	Category	Intervention Description	Extract from Source	Identified Through	Expert Feedback	Result of Feedback
49	Implementation	Pay attention to the transition from project organization to asset management organization.	”Pay attention to the transition of a project from the project organization to the asset management organization. Consider how an asset manager or operator should handle the circular construction.”	Empirical approach	Similar to intervention 40.	Combined with intervention 40
50	Implementation	Product-based approach	”Collaboration in the construction industry is through the traditional project-based management, which hampers innovation scalability, change and growth of the sector... there is a positive connection between a construction ecosystem implementing a product-based approach and the extent of partner alignment being performed by the lead firms as well as a stronger iterative use of orchestration mechanisms to achieve partner alignment.”	Theoretical approach	Can be combined with program approach. Make it more appealing for the market to make investments.	Combined with intervention 25
51	Implementation	Product-oriented standardization	-	Expert interviews	Focusing on standardization of products ensures compatibility, easier maintenance, and better reuse, which supports circular economy goals and promotes efficiency across industries.	Included in Q-set

F

Q-sort Script

This Q-sort script is in Dutch, as all participants are fluent in Dutch.

Voorstelronde / Introductie onderzoek:

- Mezelf voorstellen
- Expert voorstellen: Functie, ervaring met circulariteit in aanbesteding
- Doel onderzoek: In kaart brengen van perspectieven over interventies voor opschaling van circulaire aanbesteding van bruggen en viaducten

Introductie Q-Methodology:

- Q-methodology: onderzoeksmethode voor het omzetten van subjectieve meningen in data
- Geïnterviewde rangschikt interventies op basis van eigen ervaringen en opvattingen

Uitvoering van de Q-sort uitleggen:

1. Voorbereiding:
    - 25 kaarten met interventies (naam voor, beschrijving achter)
    - Interventies uit literatuur en praktijkdocumenten, teruggebracht tot 25 door expert interviews
    - Kaarten plaatsen op sorteerbord van minst effectief (-3) naar meest effectief (+3)
2. Condition of instruction:
    - Rangschik interventies op effectiviteit voor opschaling van circulaire bruggen en viaducten vanuit de opdrachtgever
    - Definitie circulariteit: hergebruik van bestaande kunstwerken en toekomstig hergebruik faciliteren
3. Pre-sort:
    - Interventies verdelen in drie stapels: minder effectief, neutraal, meer effectief. Om het sorteren zo makkelijker te maken
4. Sorteren:
    - Interventies op sorteerbord plaatsen, leg uit dat de focus zal liggen op de discussie achteraf.
5. Interview:
    - Uitleggen dat de interviewee achteraf zal worden gevraagd om zijn gemaakte keuzes in de Q-sort te beargumenteren
6. Vragen:
    - Vragen of de interviewee nog vragen heeft over de uitleg van het Q-sort process

Interview na Q-sort:

- Waarom [Interventie X] en [Interventie Y] als meest effectief gerangschikt?
- Waarom [Interventie A] en [Interventie B] als minst effectief gerangschikt?
- Waarom [Interventie C] en [Interventie D], etc. in de neutrale categorie geplaatst?
- Mist u nog interventies die belangrijk zijn?
- Waren de interventies duidelijk geformuleerd en makkelijk te begrijpen?

Afronding

- Bedankt voor deelname, uw inzichten zijn waardevol voor het onderzoek
- Melden dat het resultaat opgestuurd zal worden als het af is

G

Correlation Matrix

Participant	RWS1	RWS2	PRO1	PRO2	PRO3	GEM1	GEM2	MA1	MA2	MA3	MA4	KE1	KE2	KE3
RWS1	100	51	13	14	-1	0	11	47	49	24	27	6	30	23
RWS2	51	100	19	7	31	20	31	71	60	19	44	26	19	4
PRO1	13	19	100	-37	-27	51	53	27	4	-20	27	-6	17	17
PRO2	14	7	-37	100	10	-50	-47	11	0	10	3	-3	3	9
PRO3	-1	31	-27	10	100	23	3	26	36	19	1	37	14	-13
GEM1	0	20	51	-50	23	100	49	17	23	-17	24	39	34	20
GEM2	11	31	53	-47	3	49	100	40	29	14	29	14	20	-24
MA1	47	71	27	11	26	17	40	100	60	39	47	33	50	-19
MA2	49	60	4	0	36	23	29	60	100	57	27	50	29	27
MA3	24	19	-20	10	19	-17	14	39	57	100	31	6	39	16
MA4	27	44	27	3	1	24	29	47	27	31	100	-4	34	30
KE1	6	26	-6	-3	37	39	14	33	50	6	-4	100	26	13
KE2	30	19	17	3	14	34	20	50	29	39	34	26	100	0
KE3	23	4	17	9	-13	20	-24	-19	27	16	30	13	0	100

Table G.2: Correlation matrix of participants in the Q-sort activity

H

Perspective Interpretation

Perspective 1

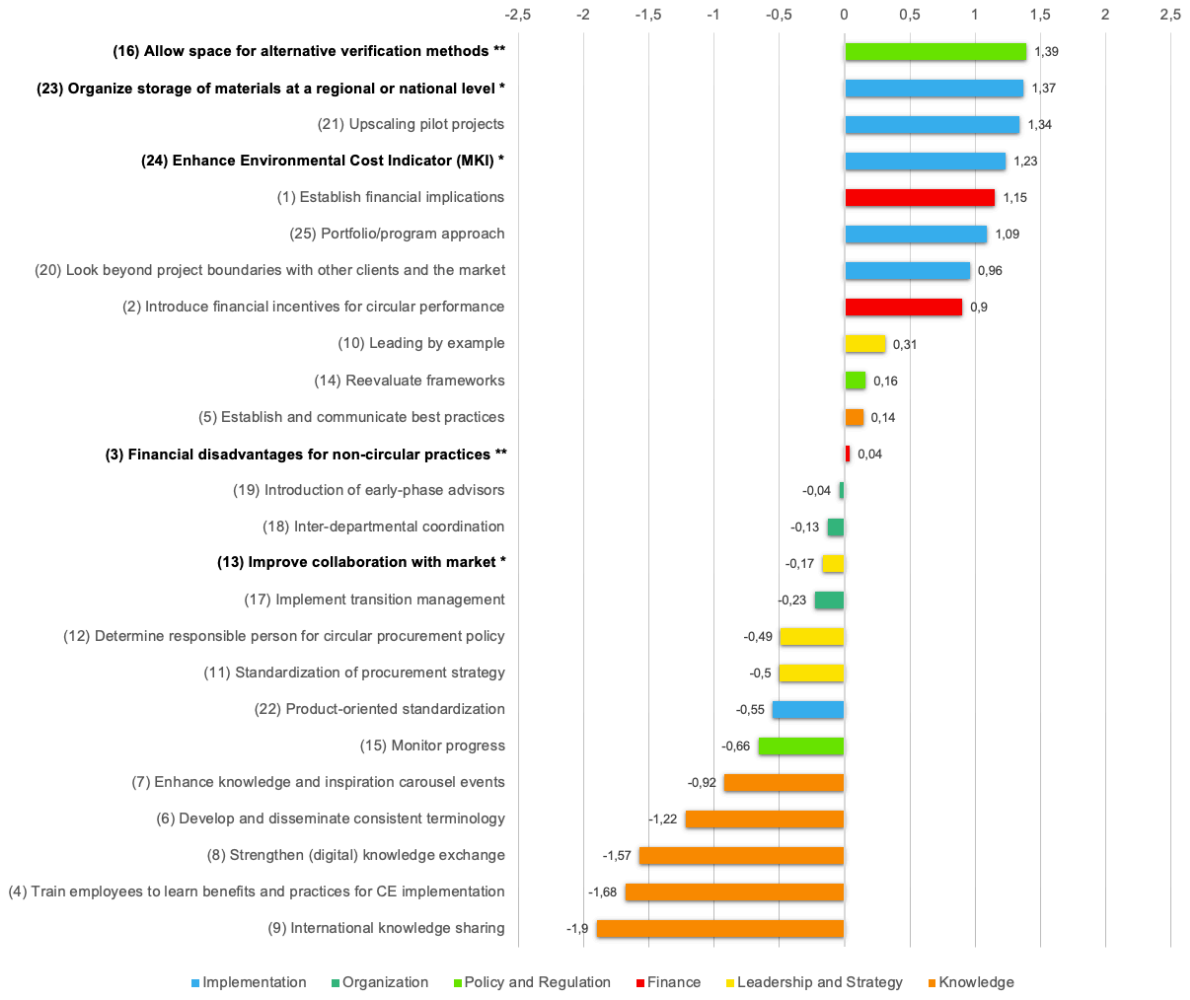

Figure H.1: Mean Z scores for perspective 1.
*' * ' indicates a distinguishing statement, significant at p < 0.05.*
*' ** ' indicates a distinguishing statement, significant at p < 0.01.*

Perspective 1 is formed by participants RWS1, RWS2, MA1, and MA4, and it stands out due to its strong focus on practical, action-oriented solutions in the context of upscaling the procurement of circular viaducts and bridges. The graph presented in Figure H.1 represents the mean Z-scores of the 25 interventions as ranked by participants in Perspective 1. This perspective stresses the importance of flexibility in standards, logistical coordination, and regulatory tools that can promote circularity. The participants in this group prioritize action-oriented strategies, such as pilot projects and enhancing existing environmental indicators like the MKI (Environmental Cost Indicator). At the same time, interventions related to knowledge-sharing and training are viewed as less critical. This perspective highlights a preference for making tangible progress through piloting solutions and refining verification methods.

Most important interventions

1. The highest ranked intervention in this perspective is the need for **"Allow space for alternative verification methods"** (Z = 1,39; distinguishing statement). Participants from both Rijkswaterstaat and the market agree that traditional verification methods are not suitable for circular construction processes, which often involve innovative technologies and materials. RWS2 explains:

   "You can't just use standard provisions and verification methods. These materials don't come from the usual factory, so you need alternative ways to verify whether a beam is suitable."

   This is echoed by MA1, who adds that alternative methods must be allowed to prove whether circular innovations are viable, stating:

   "Innovative technologies and methods often deviate from existing standards, for which calculation methods or norms are not yet available. This requires more time and money, but it is necessary to show that something is possible and safe."

   Both participants stress that while alternative verification methods may initially require more effort and resources, they are essential for proving the viability and safety of new circular innovations. MA1 underscores that this extra effort is necessary:

   "In the beginning, this will cost more time and money because you can't simply check off a list; you actually have to do the calculations. But this is needed to demonstrate that it's possible and safe. Once this has been successfully proven several times, you can start developing new standards so that it eventually becomes the new norm. But the first step is to allow these alternative approaches."

   The alignment between RWS and market participants reflects a shared recognition that the current regulatory framework needs to be more adaptable to accommodate circular innovations. As MA1 points out, sectors like asphalt have already made progress in using alternative verification methods, offering a potential model for the more conservative concrete industry. This intervention is seen as a key step in creating flexibility within the system, which is essential for scaling up circular projects.

2. **Organize storage of materials at a regional or national level** (Z = 1,37k distinguishing statement) is another intervention highly valued by Perspective 1 participants. In circular production, there is often a need to store materials between donor and destination projects. RWS2 highlights the importance of organizing this process efficiently, stating:

   "In circular production, you're always dealing with matching materials between a donor project and a destination project. In between, materials need to be stored, and that storage process has a significant impact on the business case."

   Both RWS2 and RWS1 acknowledge that long-term storage can present significant risks for commercial parties, especially when civil projects face delays. RWS1 adds:

   "Who takes responsibility, and who is going to invest? This requires leadership. Either the market passes on the storage costs, or the government takes responsibility for a storage site. But in the end, it's the government that bears the cost."

This shows a shared understanding between market and government sectors that an effective solution must be found, perhaps through public-private partnerships. RWS1 also explains that while the sector is still figuring out how to handle storage efficiently, the issue is becoming increasingly clear:

"If we don't take responsibility for storage, the business case currently becomes too risky. We have already had experiences where we had to pay extra because storage costs made the project financially unviable. This seems to be a crucial aspect."

Both participants emphasize that resolving storage challenges is fundamental to making circular procurement feasible, particularly for more complex materials like beams, which require longer storage times before reuse.

3. **Enhance Environmental Cost Indicator (MKI) (Z = 1.23, distinguishing statement)** is viewed as a effective tool for promoting circularity, particularly by market participants. MA1 explains that adjusting the MKI to give greater weight to reuse can incentivize more sustainable practices:

   "If you increase the weight of the MKI, you can steer more towards reuse. It doesn't have to be reuse specifically; it can also contribute to sustainable work in other ways."

   They note that while the MKI includes circularity and reuse, these aspects currently receive less attention compared to other factors like greenhouse gases and CO2 emissions. MA4 also supports the use of the MKI but suggests it could be further improved by incorporating elements such as standardization and design for disassembly. They state:

   "The MKI is already widely used in practice in the Netherlands, and there is no resistance to its use, making it a very effective tool to further stimulate circular solutions."

   Participants agree that the MKI is a trusted and effective instrument, but adjustments to its scope and focus could make it even more powerful in promoting circularity.

Least effective interventions

1. Participants in Perspective 1 tended to view **financial disadvantages for non-circular practices** (Z = 0,04; distinguishing statement) as less impactful. There is a shared preference for rewarding positive behavior rather than penalizing non-circular actions. RWS1 notes the importance of balancing both incentives and penalties, stating:

   "In this transition phase, you need both, but I think the advantages should weigh more, especially through portfolio approaches. For instance, bonuses for taking extra steps toward circularity.".

   MA1 has a similar opinion on this, stating a favor of a more positive approach:

   "I'm always in favor of a positive approach. So, I would rather reward new circular practices than penalize old ones.".

   The preference for incentives over penalties suggests that participants feel a punitive approach is less effective for encouraging innovation and driving the adoption of circular practices, especially in the early stages of transition.

   RWS2 says that while it may be logical to eventually price the disadvantages of non-circular practices, they caution against going too far:

   "It makes more sense that, in the end, you price the disadvantages, especially when they involve external costs. But I wouldn't want to go beyond that."

   This further highlights the group's hesitancy to overly focus on penalizing for non-circular behavior, preferring instead to stimulate circularity through more constructive and supportive measures.

2. The participants had mixed views on **improve collaboration with the market**(Z = -0.17; distinguishing statement) , which resulted in it being ranked lower than the average mean Z score. RWS1 highlights the importance of early engagement with the market, noting that market consultations allow for a better understanding of how ambitious a project can be:

"I think it's very important. Through market consultations, you can pick up early signals about how ambitious a project can be. For example, you can use the MKI more sharply with a higher weighting factor.".

They argue that such consultations are essential for ensuring that both the public sector and market actors can realistically achieve circularity goals. However, MA4, coming from the market side, interestingly offers a contrasting view. They argue that the public sector should take the lead in defining the scope and framework of circular procurement, rather than allowing the market to have too much influence:

"I think the societal task should be leading, with the needs of the contracting authority at the center. While market consultations are valuable for discussing circularity and raising awareness, they should not be decisive in setting the frameworks for circular applications."

This tension between collaboration and control reflects a broader uncertainty about how much freedom the market should have in shaping circular procurement strategies. MA4 stresses that the contracting authority should clearly define what needs to be done, with the market then responding to those needs, rather than influencing the scope too much.

Interestingly, MA1 offers a more positive example of market collaboration, but in a specific project context:

"In this project, I see that collaboration with the market is going very well. How we are working together with Rijkswaterstaat and eight market parties to move this forward is a beautiful example."

This case-specific success showcases the potential of market collaboration, but it seems that the participants in Perspective 1 are cautious.

3. The **standardization of the procurement strategy** (Z = -0,50) is another intervention that received a relatively low score. RWS1 explains that while having a standardized procurement strategy provides a framework, the lack of concrete investment commitments undermines its effectiveness:

   "The procurement strategy does provide some standards, and you should definitely keep doing that. But what's even more important is that there is real commitment in terms of investment volumes. At the moment, it remains a rather hollow document.".

   RWS1 says that the procurement strategy, while helpful in theory, falls short because the market does not know what to expect:

   "It gives the market some perspective, but it remains weak because the market doesn't know what to expect. It's like not knowing if they're going to order cake, steak, or something else."

   This uncertainty creates a barrier for the market, making it difficult for companies to plan and respond effectively to circular procurement requirements. Without a clear link to concrete financial investments, the standardization of procurement strategies is seen as lacking the necessary impact to drive meaningful change.

Conclusion

Perspective 1 centers around practical, action-oriented strategies that emphasize flexibility in regulations, logistical coordination, and refining tools like the Environmental Cost Indicator (MKI). Both Rijkswaterstaat and market participants favor solutions that can be immediately implemented, such as allowing alternative verification methods, organizing material storage, and adjusting the MKI to place greater emphasis on circularity.

There's a shared preference for encouraging positive circular practices over penalizing non-circular ones, with financial incentives viewed as more effective than imposing disadvantages. Opinions on market collaboration are varied: while it can work well in specific projects, participants feel the public sector should retain clear authority in setting the frameworks for circular procurement. Additionally, the standardization of procurement strategies is seen as ineffective without solid investment commitments, making it difficult for the market to plan and respond effectively.

In conclusion, this perspective can be called **"Practical Circularity"**, as it focuses on flexible, hands-on approaches to pushing circular procurement forward. The participants in this group favor practical interventions that address real-world issues and lean towards rewarding positive efforts rather than imposing strict penalties or rigid rules. At its core, this view is driven by the idea that meaningful progress in circular procurement relies on adaptable solutions and concrete actions.

Perspective 2

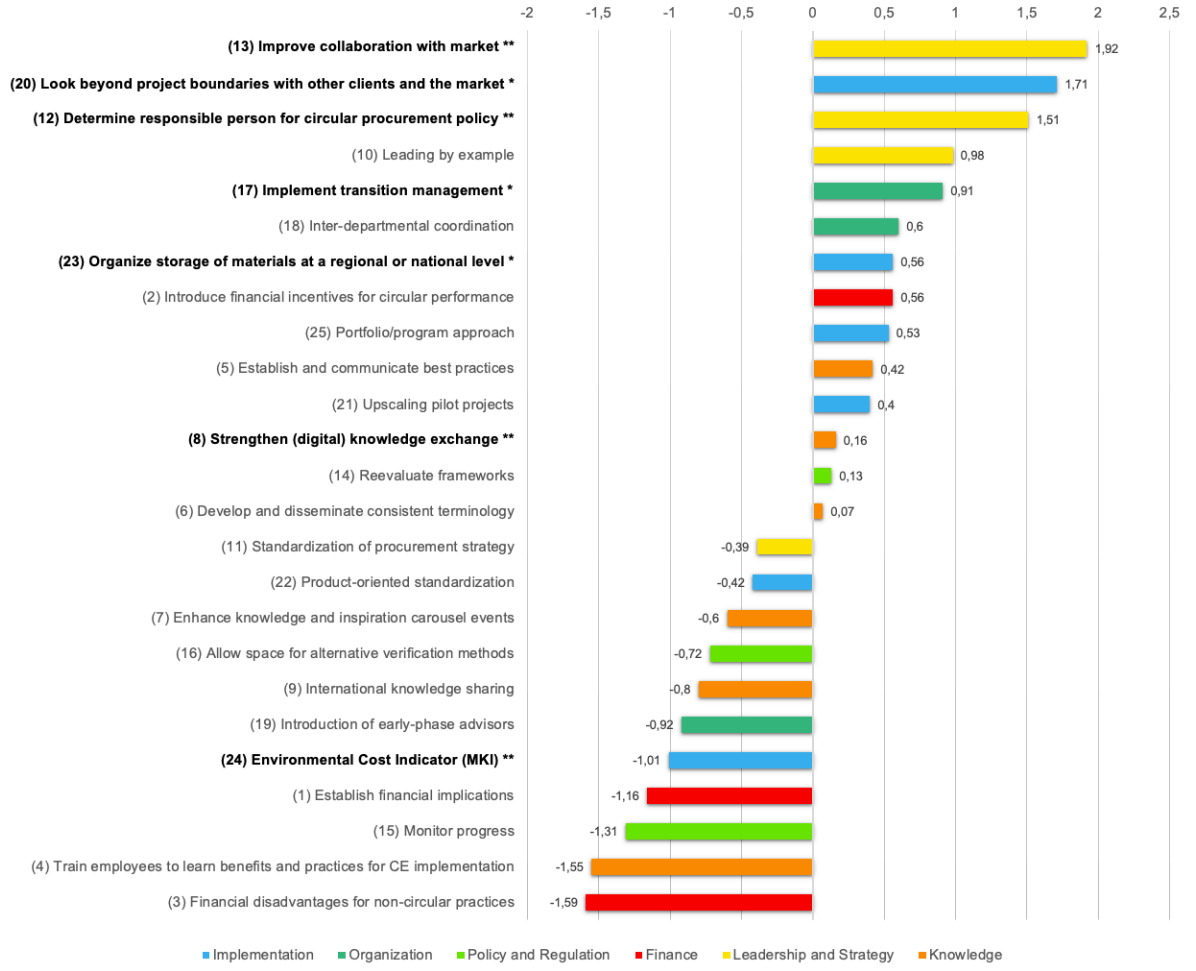

Figure H.2: Mean Z scores for perspective 2.
*' * ' indicates a distinguishing statement, significant at p < 0.05.*
*' ** ' indicates a distinguishing statement, significant at p < 0.01.*

Perspective 2 brings together participants GEM1, GEM2, PRO1, and PRO2, who focus heavily on leadership, collaboration, and accountability to move circular procurement forward. The graph presented in Figure H.2 represents the mean Z-scores of the 25 interventions as ranked by participants in Perspective 2. They believe that assigning clear responsibilities, fostering collaboration, and leading by example are key to making progress. This group sees circular procurement as a collective effort that requires direction and shared goals to succeed. Interestingly, PRO2, while technically loading on this perspective, shows a negative correlation (table 4.5. Indicating a degree of disagreement with the key interventions valued by other participants in this group.

Most important interventions

1. **Collaboration within the market and beyond project boundaries** (Z = 1,92 & Z = 1,71; distinguishing statements). Collaboration emerges as a central theme in Perspective 2, with

participants recognizing that circular procurement cannot be achieved in isolation. Both GEM1 and PRO1 stress the need for collective effort across different sectors and regions. GEM1 highlights the importance of sharing knowledge and working together with other cities facing similar challenges:

"You really can't do this alone; that's the core message. As GEM2 just mentioned, it's about sharing knowledge. We also notice at the municipal level that we can't do this alone. Other large cities are facing the same challenges, and there's a lot to learn from each other. Some cities are even ahead in certain areas, which makes collaboration so important in this transition."

GEM1's emphasis on shared responsibility is echoed by PRO1, who reflects on a project where circular ambitions were met with market hesitancy due to lack of readiness:

"You can have all the ambitions for circularity, but if the market isn't ready, it falls apart. We held a market consultation at the start of a project to replace two bridges and shared all our ideas. But what came back from the market was that, while our plans were ambitious, the market simply wasn't ready. In such a case, there's no point in setting those demands in your tender."

PRO1 also highlights the need for broader collaboration beyond individual projects or provinces. They note the complexity of aligning material availability with project timelines, which requires coordination on a larger scale:

"You can't fully realize circularity within just one project. It needs to be approached much more broadly, not just within a project or even within a province. You need to work with multiple municipalities or even at a national level to be truly successful."

These views reflect a shared understanding that circular procurement is a collaborative challenge, requiring both public and private sectors to move in tandem, with the market playing a key role in determining what's feasible.

2. **Determine a responsible person for circular procurement policy** (Z = 1,51; distinguishing statement)

   PRO1 mentions the need for clear accountability in advancing circular procurement policies. Without someone dedicated to keeping circularity on the agenda, there is a risk of falling back into traditional practices:

   "Someone needs to be clearly responsible for circular procurement policy; otherwise, it quickly fades away. If there is not someone consistently pushing and emphasizing the importance of circularity, people will revert to the standard way of working, and circularity will soon disappear from view."

   This intervention highlights the importance of leadership and accountability, ensuring that circular procurement remains a priority within an organization. The participants believe that appointing a dedicated individual is critical for keeping the focus on long-term sustainability goals.

3. **Transition management and leading by example** (Z = 0,91 & Z = 0,98; distinguishing statements)

   Participants in Perspective 2 agree that effective leadership and active transition management are crucial for driving the shift toward circular procurement. GEM2 strongly advocates for the need for decisive leadership to move beyond theory and into action:

   "It's really simple. As I mentioned earlier, if there's no leader who clearly says, 'I really want to push through with this transition,' then nothing happens. It just stays theoretical, and no progress is made. I might want it, but I'm not a leader in this organization, and that's the case everywhere."

   PRO1, as a contracting authority, emphasizes the role of the client in leading by example, particularly when it comes to managing the risks associated with circular innovations:

   "As a client, I believe it's really important to set a good example. In my opinion, the responsibility lies with the client to take the lead. Many risks in a project arise from trying new or innovative things for the first time. As a client, you're in a better position to bear those risks compared to the market, which will generally be more conservative."

Both GEM2 and PRO1 agree that leadership and clear direction are essential for driving change. They believe that contracting authorities must set the tone and lead by example, especially when navigating the uncertainties of transitioning to circular procurement. This leadership, coupled with effective transition management, is seen as key to improve innovation and making tangible progress.

Least important interventions

1. **Enhancing the Environmental Cost Indicator (MKI)** (Z = -1,01; distinguishing statement)

   Despite its widespread use in procurement, participants in Perspective 2 did not view the enhancement of the MKI (Environmental Cost Indicator) as a particularly impactful intervention. While recognizing the value of the MKI, GEM2 explains that the tool only reflects results at the very end of the process, which makes it less actionable in the context of driving circular procurement forward:

   "The MKI is nice, but at the end of the day, it only shows you the result."

   This reflects a broader feeling that while the MKI may be useful in calculating environmental impacts, it is not seen as a key driver of change. Participants suggest that while it provides a measurement of environmental costs, it may not actively push stakeholders toward more circular practices during the procurement process itself.

2. **Monitoring progress** (Z = -1,31)

   Participants also downplayed the importance of monitoring systems as a means to promote circular procurement. PRO1, in particular, expressed skepticism about the impact of monitoring, viewing them as more of a political tool than something that truly drives change:

   "Yes, it's good to monitor what you've done, but I don't think it's going to be the driving force behind a circular project. It's more important to just take action and actually do it. Such a monitoring system might be nice for politics, to show what's been achieved, but for the actual implementation, it does not add much. It feels more like something for show than a tool to stimulate real change."

The outlier

In Perspective 2, there is an interesting outlier in the form of PRO2, whose views diverge from those of the other participants on several key interventions. While GEM1, GEM2, and PRO1 tend to align in their focus on leadership, collaboration, and accountability, PRO2 expresses more skepticism regarding the effectiveness of certain interventions. For instance, regarding the responsibility for circular procurement policy, PRO2 states:

"To be honest, I find our procurement policy rather invisible. I could not tell you exactly what it entails. It seems very transparent, but in practice, I rarely come across it. What we do isn't really driven by that policy."

This contrasts with the emphasis that other participants place on having a clear person responsible for driving circular procurement. PRO2's viewpoint suggests a disconnection between procurement policies and their practical application, reflecting a sense that the policy itself lacks influence in day-to-day operations.

Similarly, when it comes to collaboration with the market, PRO2 again offers a more critical perspective. While other participants highlight the importance of close market collaboration, PRO2 questions its practical value in certain contexts, saying:

"Collaboration is important, but I wonder what it actually means in practice. If we, as a province, give a clear, sustainable assignment and choose a good contract like a RAW specification, then the market knows what's expected and can simply deliver. For innovation partnerships, close collaboration is needed, but for standard work, it seems less essential."

This view challenges the more collaborative stance taken by other participants in Perspective 2, suggesting that for more routine projects, detailed collaboration may not always be necessary.

Interestingly, PRO2 does place higher importance on mandatory training, which contrasts with the views of the other participants. They note:

"When you talk to colleagues about circularity or sustainability, some know what it's about, but others really have no idea. They mention examples that make me think: that's not what we mean. There's often confusion about what exactly circularity is and what goals we're trying to achieve. Once everyone understands what it means, we'll move in the same direction faster."

PRO2 supports mandatory training to ensure clarity and shared understanding across teams, emphasizing that without this foundational knowledge, progress can stall due to miscommunication and unclear expectations.

Overall, PRO2's views serve as a counterpoint within Perspective 2, providing a more critical lens on the value of certain interventions. While they agree on the need for clarity and practical action, their reservations about policy and collaboration reflect a more cautious approach to implementing circular procurement strategies.

Conclusion

Perspective 2 centers on leadership, collaboration, and accountability, with participants GEM1, GEM2, PRO1, and PRO2 largely advocating for practical, collective efforts to drive circular procurement forward. This perspective emphasizes the need for clear leadership and shared responsibility to foster meaningful change. Participants believe that circular procurement should be approached as a collaborative challenge, requiring alignment between public and private sectors and effective leadership that inspires action across the entire supply chain.

The recurring theme in this perspective is that progress hinges on collaboration, both within the market and across organizational or regional boundaries. Participants emphasize that no single organization can tackle circular procurement alone, and that success depends on working together to share knowledge, resources, and responsibilities. Moreover, participants strongly feel that leadership must be demonstrated by those in positions of authority, who need to take bold steps in setting examples for others to follow.

However, an interesting dynamic exists with PRO2, who, despite loading on this perspective, expresses some differing opinions, particularly around policy and collaboration. They view the procurement policy as less influential in practice and question the necessity of close collaboration in routine projects. This divergence in opinion suggests that while the core of Perspective 2 focuses on shared responsibility and leadership, there are nuances and differing levels of commitment among the participants regarding how these goals should be achieved.

In the words of GEM2, *"Everything we do—whether it's through a portfolio approach, alternative methods, or revising guidelines—ultimately serves to facilitate transition management and leading by example. That's how I view the whole process."* This summarizes the main point of Perspective 2 well: practical action, driven by leadership and collaboration, is seen as the best way to push the circular procurement agenda forward.

In conclusion, this perspective can be called **"Collaborative circularity"**, as it highlights the importance of collective effort, clear leadership, and shared responsibility in advancing circular procurement. While there is a shared focus on practical solutions, the nuances within the group show that the path forward requires both structural and relational adjustments to ensure long-term success.

Perspective 3

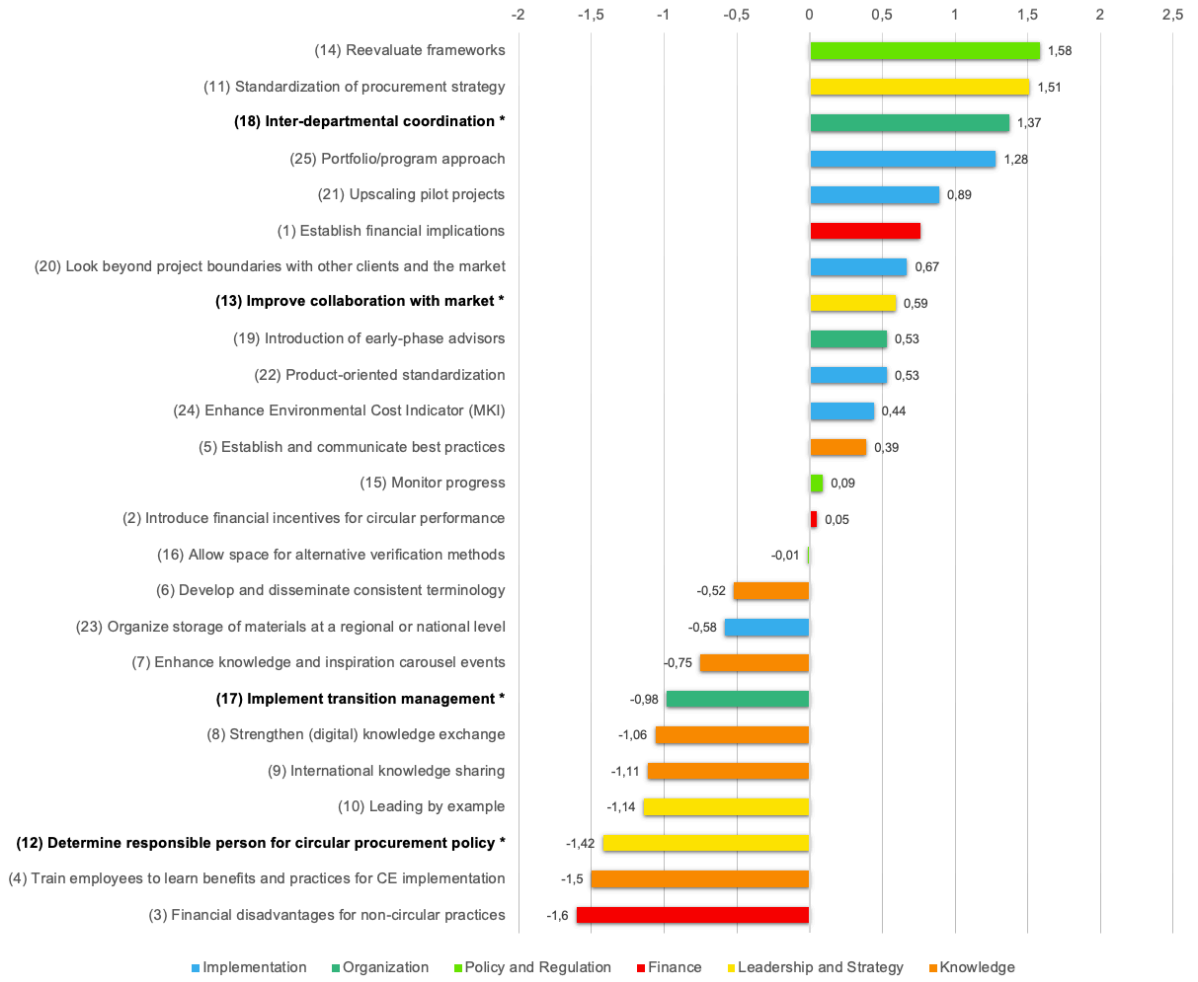

Figure H.3: Mean Z scores for perspective 3.
*' * ' indicates a distinguishing statement, significant at p < 0.05.*
*' ** ' indicates a distinguishing statement, significant at p < 0.01.*

Perspective 3 includes participants KE1, MA2, and PRO3, who stress the importance of internal coordination, the standardization of procurement strategies, and the reevaluation of frameworks as central interventions to advance circular procurement. The graph presented in Figure H.3 represents the mean Z-scores of the 25 interventions as ranked by participants in Perspective 3. They focus heavily on creating an environment where clear guidelines and shared objectives across stakeholders lead to meaningful progress. This perspective underlines the importance of collaboration within organizations, supported by clear frameworks, as well as creating conditions where market certainty encourages innovation.

Most important interventions

1. **Reevaluating frameworks (Z = 1.58)** is seen as a top priority for the participants in Perspective 3, particularly when it comes to adapting to new, innovative materials and methods in circular procurement. PRO3 highlights the challenges faced in the construction of bridges and viaducts, where rigid safety regulations limit the use of newer materials that don't yet fit within existing guidelines:

   "When dealing with bridges and viaducts, you're bound by strict laws and regulations, especially regarding safety. If you're working with innovative materials that aren't yet incorporated into

the Eurocodes, you have to prove they meet strength requirements. That process is often time-consuming and costly, so it would be useful to have better guidance on how to manage this."

PRO3 also stresses the need for leadership from larger municipalities and government bodies to drive the reevaluation of these frameworks, ensuring that smaller municipalities, which might not be as active in the transition, can still benefit:

"There are certainly frontrunners in the Netherlands, such as Rijkswaterstaat, some provinces, and large municipalities, that are actively working on this transition. But we must not forget that a large portion of the infrastructure in the Netherlands is managed by smaller municipalities and provinces, which are less active in the transition and stick to standard RAW contracts and guidelines. If the frameworks and guidelines are revised, and sustainable practices are embedded by the frontrunners in working groups, you ensure that the whole country can benefit from them at once."

Similarly, MA2 acknowledges the restrictive nature of the current guidelines and how they can be a barrier to new initiatives:

"I've often heard that the current guidelines we have for viaducts and concrete are actually a hindrance to bringing new initiatives forward."

2. **Internal-departemental coordination** (Z = 1,37; distinguishing statement) is considered as an important intervention by participants in Perspective 3, as achieving circular procurement depends on the ability of different departments within an organization to align and work toward the same goals. PRO3 explains how success is largely depended upon fostering a unified internal effort:

   "Internal collaboration is really the key for me. If you can get everyone internally on the same page and working toward the same goal, you can achieve a lot together. The success or failure of circular procurement depends on how well you can create that shared focus."

   KE1 adds that this alignment goes beyond just terminology—it requires consistent processes that are agreed upon and adhered to across departments:

   "To make this work, you need standards, clear ways of working, and consistency—not just in terminology, but also in how projects are managed. How you handle circularity in your projects and how that fits into your internal organization has to be in sync. That's what leads to the right actions at the right moments, which in turn impact various stages of design and procurement."

   This shared understanding and coordinated effort within organizations create the foundation for more successful external collaborations and more effective circular procurement strategies.

3. **Standardization of procurement strategy** (Z = 1,51) is viewed as another imporatnt intervention for participants in Perspective 3. KE1 highlights the importance of having clear and consistent procurement processes, particularly when dealing with circularity. They stress that maintaining simplicity in the design, especially for projects like bridges, is crucial for longevity and sustainability:

   "The market works as you would expect: there's a tender, a question is asked, and the market does its best to meet that demand. But the more flexibility you allow, the more variation you get in the offerings. Sometimes that's good, but with circularity, and especially for bridges, it needs to be kept simple. The design needs to be modular, longer-lasting, or capable of being renovated. That design decision always lies with asset management."

   KE1 also points out the risks of allowing too much flexibility in procurement, especially in sectors with a high volume of transactions, noting:

   "Who are you fooling if you act like everything is freely choosable, especially in a sector with such a high volume of transactions? If we're serious about this task, we need to structure it differently. If we want to do it circularly, we need to clearly define what the interventions are, collaborate with the market, and standardize how we approach things."

KE1 argues that the approach must not only cover project-specific work but should also extend beyond project boundaries. Without such consistency, contractors will focus on securing the next project rather than building structural capacities for doing things differently. This leads back to the importance of transition management, where the focus should be on concrete actions that define what needs to happen at each stage of circularity implementation:

"If you're constantly jumping from one project to another, you're focused on winning contracts, not building structural capacities to do things differently. This brings us back to transition management, which is also important. It's about precisely determining what needs to happen and when, to realize circularity. That's where we need to focus and take concrete action."

Additionally, PRO3 emphasizes the advantages of standardizing procurement strategies, especially in terms of providing market certainty and investment security:

"Things like the MKI and working with a portfolio approach are ways to shape your procurement strategy. The more you standardize this as Dutch public authorities, the more investment certainty and recognition you create for the market. This allows companies to consistently submit tenders with products they already have, without needing to make many adjustments, which makes it easier for them."

In particular, this strategy is seen as beneficial for smaller municipalities that may have limited budgets but stand to gain from adopting standardized procurement practices that simplify circular procurement. The Buyer Group's circular procurement strategy for viaducts and bridges is mentioned as a good example of how municipalities can choose their level of ambition while still benefiting from a standardized approach.

Least important interventions

1. Participants in Perspective 3 rated **implementation of transition management** (Z = -0.98; distinguishing statement) as less effective. Both PRO3 and KE1 shared their reservations, though for different reasons. PRO3 expressed that a dedicated transition manager might not be necessary if internal coordination is already strong:

   "I don't think you need a transition manager if internal collaboration is good. If you can align everyone internally and have a clear, shared goal, then a transition manager becomes redundant. However, it is important to have people on staff who understand sustainability and know what they're doing—that makes the process much easier."

   On the other hand, KE1 believes that while transition management as a concept is valuable, it does not necessarily drive results on its own. The focus should be on translating insights into concrete actions:

   "Implementing transition management is nice, but in fact, the measures we are taking are all part of transition management. I find transition literature inspiring and insightful; it gives you a good idea of what to do. But just adopting transition management does not mean you're truly in a transition. It's about taking concrete measures based on those insights that lead to real results. And that's exactly where I focus—on the step from insight to action."

   In both views, the key takeaway is that while transition management may provide a useful framework, it's the practical, actionable steps that make the real difference. The skepticism towards the role of a dedicated transition manager reflects the belief that internal collaboration and targeted action are more crucial for driving progress in circular procurement.

2. The idea of using **financial disadvantages for non-circular practices** (Z = -1.6) was also met with some resistance in this perspective. PRO3 acknowledged the potential benefits of taxing primary raw materials but pointed out that such measures fall outside their control as a provincial government:

   "Yes, raising the costs of primary raw materials through taxes could be a solution, but we as a province have no control over that; that's up to The Hague. That makes it complicated. At some point, primary raw materials will naturally become expensive enough that reused materials will be more attractive to the market. I think that process should be left to the market."

KE1, meanwhile, felt that financial penalties were unnecessary if circular practices are well-organized within projects:

"How you handle circularity in your projects and how that is integrated within your internal organization must be aligned. This should lead to the right interventions at the right moments, which will then carry through different phases of the design and eventually into the procurement strategy you use for tendering. That way, the market can actually do something with it, and various forms of market collaboration will emerge. If it's well-organized, you don't need extra incentives. You don't need to penalize second-hand materials or create artificial market forces. If it's well-organized, it works by itself."

The overall sentiment suggests that while financial penalties could play a role in the future, participants believe that effective organization and procurement strategies will naturally lead to more circular practices without needing to rely on punitive measures.

3. **Organize storage of materials at a regional or national level** (Z = -0.58; distinguishing statement) There was a noticeable split in opinions regarding the effectiveness of organizing material storage at a regional or national level, particularly between market and knowledge institution participants. MA2, representing the market, felt that while the concept might be sound, it would be overly complicated for governments to manage and suggested leaving it to the market:

   "I placed this more to the left (indicating less importance), because while I think the idea is good in principle, I believe that governments will only make it more complicated if they handle it this way. The way I interpret it, it would no longer be the government's responsibility, and that seems overly bureaucratic to me. I think it would be better to leave this kind of thing to the market."

   In contrast, KE1, representing a knowledge institution, argued that the market alone cannot solve the issue due to fluctuating storage costs and the long periods materials might remain in storage:

   "Storage is definitely an important issue, but it only becomes a real problem when we start creating large volumes. Once there's demand for the reuse of materials, like beams, storage will partially solve itself, but it remains a coordination issue. The market won't solve this by itself, especially because storage costs fluctuate, and materials can stay in storage for a long time. This is tricky, particularly if contractors or engineering firms have to bear those costs. It's important to first learn and test various storage strategies before choosing one solution."

   This contrast underscores the differing perspectives: the market participant prefers a market-driven solution, while the knowledge institution participant believes that the market lacks the capability to address storage challenges on its own, highlighting the need for coordinated strategies.

Conclusion

Perspective 3 includes participants KE1, MA2, and PRO3, who stress the importance of internal coordination, the standardization of procurement strategies, and the reevaluation of frameworks as central interventions to advance circular procurement. They focus heavily on creating an environment where clear guidelines and shared objectives across stakeholders lead to meaningful progress. This perspective underlines the importance of collaboration within organizations, supported by clear frameworks, as well as creating conditions where market certainty encourages innovation.

Participants agree that without internal alignment and standardized strategies, it is difficult to achieve lasting change. The standardization of procurement processes, in particular, is seen as a key factor in making circular practices scalable and feasible across various sectors. They also emphasize the need for flexibility within regulations to allow for the use of innovative materials, which will be essential in advancing circular viaducts and bridges

While they see the value in these structural interventions, they are more skeptical about certain mechanisms like implementing transition management or imposing financial penalties for non-circular practices. For them, these measures seem less crucial than fostering strong internal collaboration and clear procurement strategies that align with circular goals. There is also a split opinion on organizing material storage, with market participants favoring a market-driven solution, while

knowledge institutions argue that coordination and oversight are needed to address the complexities of storage logistics.

In conclusion, this perspective can be summarized as **"Tactical Circularity,"** as it places a strong emphasis on building structured, consistent processes and procurement strategies to advance circular procurement. Participants in this group advocate for clear, actionable frameworks that allow for the practical integration of circular principles while ensuring market stability and internal coordination. They believe that with the right internal systems in place, circular procurement can become a natural part of project execution, reducing the need for more prescriptive or punitive measures.

Perspective 4

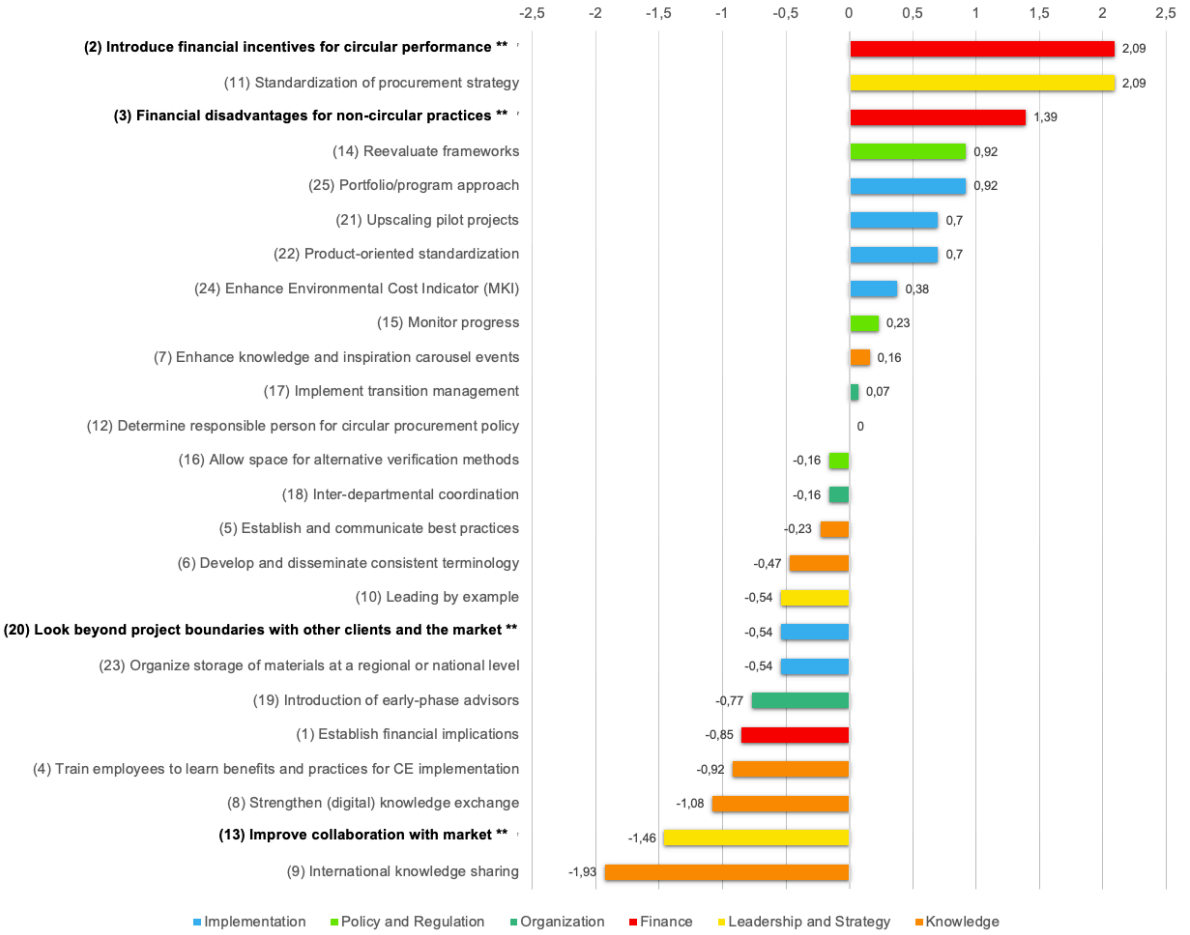

Figure H.4: Mean Z scores for perspective 4.
*' * ' indicates a distinguishing statement, significant at $p < 0.05$.*
*' ** ' indicates a distinguishing statement, significant at $p < 0.01$.*

Perspective 4 brings together participants MA3 and KE3, who underscore the importance of financial incentives, procurement standardization, and financial penalties to support circular procurement. The graph presented in Figure H.4 represents the mean Z-scores of the 25 interventions as ranked by participants in Perspective 4. This group places a strong focus on creating financial frameworks that reward circularity while discouraging non-circular practices. They see standardizing procurement as a way to ensure that circular methods become mainstream rather than optional. Additionally, there is a notable skepticism toward the need for extensive collaboration with the market, with participants feeling that the government should take a leading role in pushing circular practices forward.

Most important interventions

1. **Financial incentives for circular performance and financial disadvantages for non-circular practices** (Z = 2,09 and Z = 1,39; distinguishing statements) Participants in Perspective 4 place significant importance on creating a financial environment that both encourages circular practices and discourages non-circular ones. MA3 highlights that the current system makes it easy and financially attractive to buy new materials, while circular options often incur higher costs:

   "What you see now is that it's still quite easy to purchase new materials without being penalized for higher CO2 emissions. This makes circular materials less efficient and often more energy-intensive and expensive, not just in demolition or harvesting, but throughout the entire process."

   They stress the need for financial mechanisms that not only make circular materials more attractive but also penalize higher-emission products through increased CO2 taxation:

   "Circular applications need to become financially more attractive, for instance by weighting circular options more heavily in the MKI. At the same time, we need more CO2 taxes on higher-emission products, so there's a financial incentive to work circularly."

   KE3 has the same opinion and further elaborates that beyond setting a base level for circular procurement, there should be clear rewards for companies that exceed circularity expectations:

   "If a party takes more circular measures, they should get recognition or benefits for it. This encourages circular behavior and discourages non-circular practices. That way, you ensure that circular efforts are rewarded, and the right behavior is incentivized."

   While both participants highlight the importance of balancing financial incentives and penalties, the perspective leans more toward creating positive financial incentives that drive the adoption of circular practices. The belief is that rewarding circular actions will be more effective in promoting change than purely penalizing non-circular behaviors.

2. **Standardization of procurement strategy** (Z = 2,09)

   Standardizing procurement processes is seen as a vital step in Perspective 4 for advancing circular procurement at scale. MA3 stresses that procurement strategies need to be more proactive, requiring upfront decisions that ensure circular materials are available for reuse:

   "For example, reusable beams need to be harvested in every project. If you don't prescribe that upfront, there won't be enough material on the market, and then you can't reuse it later. That's why I believe the procurement strategy needs to take a different course and standardize these kinds of practices."

   This proactive approach to procurement standardization ensures that the necessary materials are available, helping to facilitate a circular economy. Without such measures, there would not be enough resources in circulation to meet the growing demand for reused materials in infrastructure projects.

   KE3 echoes the sentiment that standardization is crucial to ensure that circular procurement becomes a widespread practice rather than an exception limited to a few frontrunners:

   "It's very important that everyone knows how to procure circularly, and for that, we need standardization so that everyone is more or less doing it the same way. Additionally, we need to set a realistic level that everyone can achieve. If that's done right, you can ensure that the majority starts procuring circularly, not just a few frontrunners."

   KE3 mentions that procurement processes need to be standardized across the entire civil sector to create consistency and predictability. This standardization would not only make circular procurement more accessible but also ensure that even smaller municipalities, with limited budgets and resources, can participate in the circular economy. They also highlight the importance of recognizing and rewarding those who take extra steps toward circularity, thus creating a balanced system of rewards and incentives.

The key takeaway from both participants is that standardization is essential for creating a level playing field in circular procurement, ensuring that circular practices are embedded at every stage, from project initiation to final delivery. Standardization also provides a clear framework that simplifies decision-making and encourages broader adoption of circular principles across the sector.

Least important interventions

1. **Improve collaboration with the market** (Z = -1,46; distinguishing statement) Participants in Perspective 4 rated collaboration with the market as one of the least effective interventions for driving circular procurement. MA3 explains that their low score stems from the belief that market consultations and research should not be a prerequisite for moving forward with circular goals. They argue that once the government has committed to certain objectives, such as those outlined in the Paris Agreement or the Raw Materials Agreement, these should be pursued regardless of market feedback:

   "The reason I rated market collaboration low (-3) is because it was suggested that market research and consultations should be conducted to validate circular needs and ambitions. When I read that, I thought: if the government has committed to something and wants to go in a certain direction, it should just happen, regardless of what the market thinks."

   MA3 emphasizes that the infrastructure market is heavily driven by governmental regulations and commitments, and continuously seeking market validation would only delay progress:

   "The infrastructure market is strongly government-driven, and the government has already committed to things like the Paris Agreement and the Raw Materials Agreement. If we keep going back to validate whether the market agrees with these needs, the circular economy will never progress. That's why I rated this intervention low."

   This perspective reflects a more top-down approach, where the government takes the lead in setting circular procurement goals and expects the market to follow, rather than tailoring circular efforts based on market readiness.

2. **Leading by example** (Z = -0.54) is also rated as relatively less important in this perspective. MA3 expresses skepticism about the effectiveness of this approach, arguing that instead of focusing on symbolic leadership, concrete actions such as standardizing procurement strategies and addressing financial aspects would be more impactful:

   "Yes, if they would just do it through good policy and collaboration. If they really directed their energy toward realizing things like the standardization of procurement strategy and the financial side, I'd be happy with that. Of course, it's important to get people on board, but at the end of the day, it's about putting words into action."

   While MA3 acknowledges that inspiring others is important, they suggest that this is not the primary factor for driving circular procurement forward.

   KE2 offers a slightly different view, emphasizing the importance of leadership in motivating people to take action. They argue that without clear leadership, people are often hesitant to move forward:

   "It's very important that people are encouraged to act sustainably. If no one takes the lead, nothing happens. We often hear from managers, contractors, and engineering firms that they're waiting for others to act, and if everyone keeps saying that, nothing ever happens. You really need leaders who drive the process, activate people, and motivate them to take action."

   However, KE2 also notes that this leadership can be inconsistent, depending largely on the intrinsic motivation of individuals within organizations:

   "If you have the right people, a municipality, province, or Rijkswaterstaat can really make progress. It's about leaders who not only apply change management but also bring it into practice. In some municipalities, this happens because the right people are in place. In others, nothing happens, often depending on the intrinsic motivation of staff or their leaders."

Both participants recognize the importance of leadership but agree that it is often dependent on individual motivation rather than systemic change. This leads to a lower ranking for ”leading by example” as a key intervention in this perspective, with the participants favoring more direct and structural changes to drive circular procurement.

Conclusion

Perspective 4 brings together MA3 and KE3, who focus heavily on financial mechanisms and standardization as key drivers for advancing circular procurement. Participants in this perspective advocate for financial incentives to encourage circular practices and penalties to discourage non-circular behavior. They believe that without a well-structured financial framework, circular procurement will remain an ambitious concept rather than a practical reality. This group also stresses the need for standardized procurement strategies, ensuring that circular approaches become a consistent part of public infrastructure projects rather than isolated examples.

A recurring theme in this perspective is the importance of financial levers in driving behavioral change. Both MA3 and KE3 agree that creating financial incentives for circular actions and applying penalties for non-circular practices can shift market behavior toward more sustainable solutions. They believe this approach will help scale circular practices and make them financially viable, especially in sectors where circular options currently face higher costs. In addition, procurement standardization is viewed as essential for creating a level playing field. Participants argue that without clear, consistent procurement guidelines, circular practices will remain optional or inconsistent. Standardization ensures that circular methods are embedded in every project, providing the market with the certainty needed to develop and supply circular solutions at scale.

However, Perspective 4 shows a strong skepticism toward relying on market collaboration to validate circular strategies. MA3 argues that government-driven commitments, such as those in the Paris Agreement, should be implemented without waiting for market input, as too much reliance on market consultation can delay progress. This highlights a preference for top-down governance, where the government sets the direction, and the market follows.

In conclusion, this perspective can be called **”Financially-Driven Circularity”** as it emphasizes the role of financial incentives, penalties, and procurement standardization in advancing circular procurement. The participants in this group believe that creating a structured financial and regulatory environment is the most effective way to embed circular practices across the sector, ensuring they become the norm rather than the exception.