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Operationalizing contested problem-solution spaces: The case of Dutch circular construction

Martijn Wiarda [a,*], Tom B.J. Coenen [b], Neelke Doorn [a]

[a] Department of Values, Technology and Innovation, Faculty of Technology, Policy and Management, Delft University of Technology, Jaffalaan 5, 2628, BX, Delft, the Netherlands
[b] Department of Civil Engineering & Management, Faculty of Engineering Technology, University of Twente, Drienerlolaan 5, 7522, NB, Enschede, the Netherlands

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ABSTRACT

In shaping collective responses to societal challenges, we currently lack an understanding of how to grasp and navigate conflicting ideas on societal problems and potential solutions. The problem-solution space is an increasingly popular framework for conceptualizing the extent to which problem-oriented and solution-oriented views are divergent. However, this reflexive framework needs an operationalization to become useful in practice. We contribute to this debate by demonstrating how Q-methodology can be used to systematically identify, describe, and compare collectively held visions in relation to problems and solutions. We use the case of Dutch circular construction, and identify three conflicting imaginaries that inform us about disagreement and common ground. We conclude by discussing how policymakers can use different approaches to navigate contestation, presumably mobilizing actors for a collective response.

1. Introduction

Decision-makers are increasingly struggling with challenges that affect society and the environment (Schot and Steinmueller, 2018). These challenges frequently fall into the category of *wicked problems* because they are characterized by inherent complexity and uncertainty, which contribute to their contested nature (Head, 2008; Rittel and Webber, 1973). More specifically, contestation arises as actors embody fundamentally conflicting ideas about the nature of the problems and their required solutions (Head, 2019; Kuhlmann and Rip, 2018). Wanzenböck et al. (2020) introduced the *problem-solution space* as a theoretical framework to conceptualize the extent to which views on these problems and solutions are divergent (i.e., contested). In this increasingly popular framework, views on problems and solutions exist, unfold, and interact and may diverge or converge over time.

Divergent ideas about problems and solutions cause actors to have radically different imaginaries of (un)desirable futures. Imaginaries are intersubjective insofar that actors may (implicitly) share visions once constructed around similar values and worldviews (Jasanoff and Kim, 2015). Contestation thus emerges when different groups hold contradicting imaginaries (Hess, 2015; Kim, 2015). Contestation represents a significant challenge for decision-makers because neglecting or misunderstanding disagreement can further problematize wickedness by prompting standstills, exacerbating conflict, or creating new problems. Decision-makers do not "always 'know best' or 'act best' in understanding problems and proposed solutions" (Kirchherr et al., 2023, p. 4). They are therefore in need of novel approaches for collective sensemaking to mitigate the risk of reflexivity failures (Garud and Gehman, 2012; Weber and

* Corresponding author.
E-mail address: m.j.wiarda@tudelft.nl (M. Wiarda).

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Rohracher, 2012).

Although the problem-solution space offers an important conceptualization of the (divergence of) imaginaries surrounding problems and solutions, there is an explicit demand for the framework's operationalization (Wanzenböck et al., 2020). In the absence of this operationalization, decision-makers inadequately understand what divergent imaginaries exist, how these relate to each other, and how these are distributed among actors. Without an operationalization, decision-makers are insufficiently informed about the extent to which challenges are contested and how this contestation can be navigated. As a result, they could overlook or excluded viable problem understandings and solution pathways (Wesseling and Meijerhof, 2021).

This paper contributes to the reflexive governance of transitions (Voß and Bornemann, 2011) by demonstrating how the contestation dimension of the problem-solution space can be operationalized. It does so by illustrating how divergent imaginaries about problems and solutions can be identified, described, and compared using Q-methodology to better understand the way and extent to which challenges are contested. Q-methodology is a widely adopted research method that helps understand the heterogeneity of intersubjective perspectives (Brown, 1982; Stephenson, 1935). By revealing opposing imaginaries, our paper demonstrates how decision-makers (e.g., policymakers) can reflexively learn about alternative understandings of the problem-solution space of a given societal challenge (Feindt and Weiland, 2018). Continuously reflecting on the directionality of transformations allows for more tentative forms of governance that are more responsive to stakeholder worldviews despite interpretive flexibility (Bijker, 1987; Kuhlmann et al., 2019; Stilgoe et al., 2013).

To demonstrate this approach, we use the case of the Dutch circular construction in which the government has set out a contested imaginary, that we call *'Circular construction by 2050',* and which is being implemented through policies (Coenen et al., 2022a). Our paper therefore also provides case specific insights that could help policymakers align imaginaries for more collective responses.

In what follows, this paper first elaborates on its theoretical background (Section 2), followed by an explanation of the paper's methodology (Section 3). This section also introduces and justifies the case that is chosen for the paper. Section 4 proceeds by describing the identified imaginaries after which Section 5 compares these to understand the contestation (Section 5). The paper concludes by discussing different ways contestation could be navigated, and by reflecting on the paper's contribution (Section 6).

2. Wicked problem-solution spaces and contested imaginaries

2.1. Problem-solution spaces

Due to the enduring nature of wicked problems, solutions to these problems are deemed provisional, while the problems themselves are never solved. Provisional solutions strive to unfold "a never-ending discourse with reality, to discover yet more facets, more dimensions of action, more opportunities for improvement" (Dery, 1984, pp. 6–7). Wicked problems do therefore not have a 'stopping rule' (Rittel and Webber, 1973). Rather than 'solving' these problems, scholars speak of 'resolving', 'coping with', and 'managing' wickedness (Head and Xiang, 2016; Xiang, 2013).

The problem-solution space underlines this tentative and wicked nature of problems and solutions. Wanzenböck et al. (2020) provided various illustrative case studies to show that views on problems and solutions may diverge or converge (Fig. 1). There are, for example, increasingly more convergent views on the problem of obesity while there is widespread disagreement on which of the numerous interventions are needed to tackle this. Self-driving cars contrarily suggests that disagreement may also emerge on what problems some concrete innovations can resolve. While problems and solutions are open to dissimilar levels of contestation, developments around smoking bans, wind energy, and CCTV demonstrate how problem-oriented and solution-oriented views can both

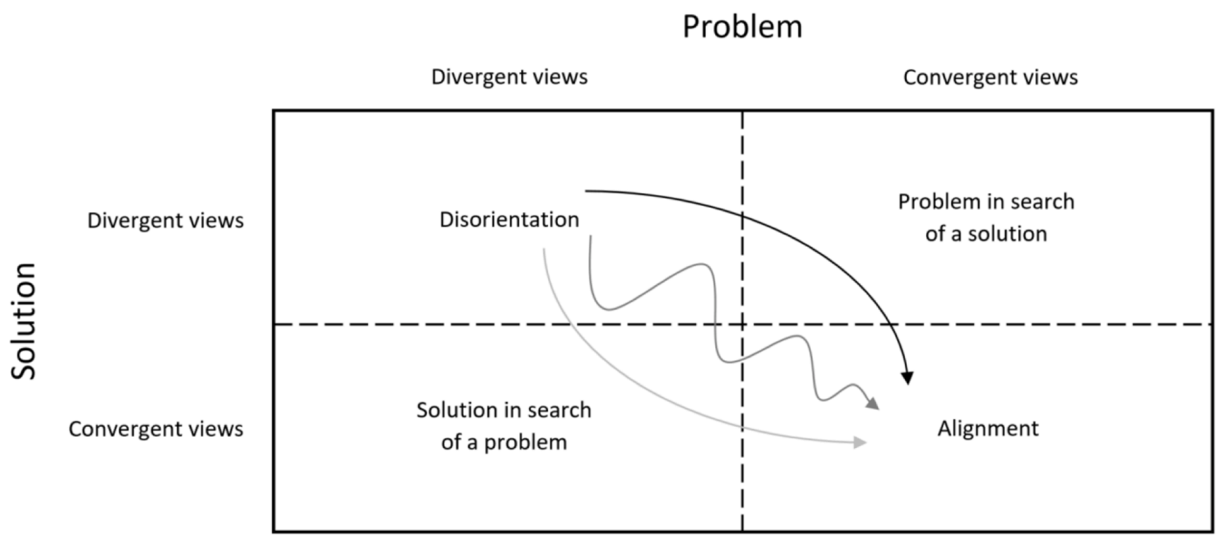

Fig. 1. The problem-solution space. Source: Wanzenböck et al. (2020).

converge over time.

Next to the convergence of problem and solution framings, framings may interact in the sense that the framing of one suggests the framing of the other (Bacchi, 2009; Ison et al., 2014; Peters, 2005). For instance, the reduction of CO_2 emissions as a solution for climate change hints that CO_2 emissions are (part of) the problem.

More fundamentally, problems are contested because they can be framed as symptoms of higher-level problems and can be explained in numerous ways (Rittel and Webber, 1973). Solutions are contested as stakeholders embody radically different, or even conflicting, values and worldviews – solutions that meet one's preferences may displease those of others (Dentoni and Bitzer, 2015; Pesch and Vermaas, 2020). The number of possible solutions is also non-exhaustive, and they are often impossible to test because it would change existing problems or create new ones (Rittel and Webber, 1973). As such, contestation often relates to the epistemic nature of problems, and the risks, uncertainties, and opportunities associated with potential solutions (e.g., Dignum et al., 2016; Ligtvoet et al., 2016). Sources of contestation are moreover exacerbated by the complexity and uncertainty associated with wickedness (Head, 2019).

Contestation is in many cases a future-oriented phenomenon because possible solutions are usually not yet developed and implemented. While contestation about future scenarios can relate to predictions (i.e., what *will* happen) and explorations (i.e., what *could* happen), it nearly always involves normative ideas (i.e., what *should* happen; Börjesona et al., 2006; Ligtvoet et al., 2016). These visions may be made explicit through the act of framing. Visions for (un)desirable futures tend to be collectively held even though only a selective group of actors actively partakes in the political discourse that emerges from explicit framings (Konrad and Böhle, 2019). Framings thus explicate only a fraction of collectively held visions in society even though nearly all visions have a performative function. As a result, disagreement is often obscured, undisclosed, and latent. An analytical shift from framings to collectively-held visions is therefore helpful in revealing and understanding contestation.

2.2. Imaginaries

Jasanoff and Kim (2015) refer to these collectively-held visions as *socio-technical imaginaries*, which they defined as: "collectively held, institutionally stabilized, and publicly performed vision[s] of desirable futures, animated by shared understandings of forms of social life and social order attainable through, and supportive of, advances in science and technology."(p.5). As such, imaginaries represent normative socio-technical visions that are held by a group of individuals and which are publicly performed (Sovacool et al., 2019). Attaining these desirable futures through science and technology suggests that imaginaries contain a strong solution-oriented view that is constructed on present-day problems. Jasanoff and Kim (2015) argued that imaginaries can be utopian or dystopian, hinting that imaginaries do not necessarily emphasize problems and solutions equally.

Imaginaries are co-constructed and enable individuals to be connected by shared narratives, norms, and discourses, without having ever met. They are thus social constructs (Bijker, 1987) that implicitly or explicitly reflect matters of concern (Latour, 2004). They lay at the nexus of how society co-produces epistemic and normative understandings of the world, i.e., how things are and how things should be (Jasanoff, 2004). Imaginaries thus have a performative function as they shape the future by steering practices in the present (Delina, 2018). Imaginaries are inherently political (Granjou et al., 2017; Konrad and Böhle, 2019; Marquardt and Delina, 2019) because they inscribe a "vision of (or prediction about) the world" (Akrich, 1992, p. 208) that imposes particular values and worldviews (Winner, 1980). Inspired by Haraway (1991, 1988), it may therefore be fitting to speak of 'situated' imaginaries as they reflect the values and worldviews of the 'imaginator'.

Indeed, governmental imaginaries that are publicly performed through policies (e.g. missions and strategies) "are associated with exercises of state power" (Jasanoff and Kim, 2009, p. 123) and tend to spark contestation (Hermann et al., 2022; Sismondo, 2020). Yet, imaginaries are not merely held by authorities such as experts and governments, but are also created, held, and reconfigured by other types of actors (Smith and Tidwell, 2016). As a result, problem-solution spaces are associated with a constellation of different imaginaries that are held by a broad range of groups. These imaginaries exist in parallel, co-evolve, and constitute what Burnham et al. (2017) call the 'politics of imaginaries'. In this political landscape, divergent views on problems and solutions are reflected by the existence of multiple imaginaries that generally clash (Hess, 2015; Levidow and Raman, 2020; Marquardt and Delina, 2019).

In this paper, we operationalize problem-solution spaces as the plurality of contradicting, often undisclosed, imaginaries that shape conflict and practices in the present. Revealing what futures should (not) look like according to different stakeholder is a crucial reflexive exercise needed to learn from disagreement (Cuppen, 2012; Ligtvoet et al., 2016). Reflexivity can therefore play an important role in the alignment of imaginaries (Fig. 1). For instance, governments could subsequently reformulate policies in a way that they resonate with the perceived problems and desirable solutions of other imaginaries (Huang and Westman, 2021). In what follows, this paper discusses the case and method used to identify and describe conflicting imaginaries in problem-solution spaces.

3. Methodology

This study aims to identify, describe, and compare divergent imaginaries as an operationalization of contestation in the problem-solution space. In what follows, we first introduce and justify our selected case study (Section 3.1.), and then explain how and why Q-methodology can be used to identify the imaginaries of its problem-solution space.

3.1. The case of Dutch circular construction: 'Circular construction by 2050′

We selected the empirical context of the government-led mission *'Circular construction by 2050′*. This case was selected for a variety of reasons. First, this circularity mission is broadly recognized to be highly contested in terms of both its problem and solution-space (Coenen et al., 2022a). The wickedness associated with circular economy is reflected by heated debates among actors. For instance, practitioners question whether circular economy could even address environmental concerns and some believe it may have become a goal in itself (Calisto Friant et al., 2020; Corvellec et al., 2022). These divergent views on problems and solutions indicate that *'Circular construction by 2050'* does not fall into the 'alignment' quadrant of the problem-solution space (Fig. 1). Moreover, its institutionally fragmented character and the sector's dependency on public funds is believed to invite hostility between public and private parties. Second, the construction sector is relevant because its large use of natural resources and waste creation suggest that a transition to circularity can have a major impact on society and the environment (Ghaffar et al., 2020). Third, although the Dutch circular construction sector is a frontrunner in the domains of waste management and reuse innovations, it is still in an early transition phase (Giorgi et al., 2022). Fourth, the Dutch government was one of the first to issue a top-down policy on circular construction. The contested problem-solution space, institutional fragmentation, high stakes, and early transition stage in combination with this top-down approach indicate that various imaginaries presumably coexist with the imaginary *'Circular construction by 2050'* that is articulated through the government-led mission. This provides for a rich empirical setting to operationalize the problem-solution space. The government-led mission and its context are as follows.

In 2016, the Dutch government set out a mission for the Netherlands to be fully circular by 2050 (IenW and EZK, 2016). This mission was divided by the ministry into five priority sectors, including construction. The construction mission includes both building construction and the infrastructure sector, and as such addresses the entire built environment. The imaginary *'Circular construction by 2050'* was accompanied by a circular economy strategy report that introduced three objectives: (1) the high-grade utilization of available resources and waste flows; (2) the substitution of fossil and non-sustainably produced resources by widely available and renewable alternatives; (3) and the rethinking of consumption in conjunction with the reconfiguration of products and production methods. The same strategy report acknowledges that circular economy should be understood as a utopian vision to mobilize actors into a shared direction. It is idealistic in the sense that attaining such a fully 'closed' system is unlikely because of inevitable waste flows.

A transition team was installed for the construction sector that contained both policymakers and representatives of various stakeholder groups, including construction firms, engineering firms, national and regional clients, knowledge organizations, and interest groups. This team issued a strategic agenda that lays out how they believe the construction sector should be transformed into a circular one by 2050 (Transitieteam bouw, 2018). It directs efforts from a policy perspective towards developing a circular market, measuring circularity, establishing and implementing policies and legislation, and enhancing knowledge production and diffusion. In addition, it functions as the main advisory group to the Ministry that is responsible for circular construction.

In 2019, the Transition Team set out annual Implementation Programs which monitored the mission's progress, prioritization, and policy landscape (BZK, 2019). Focus in these strategies shifted increasingly from addressing resource efficiency to a more integral view on environmental sustainability and economic viability, including CO_2 reduction, energy efficiency, and reducing supply risks.

However, many circularity-related efforts in the sector did not align with the strategy presented by the Transition Team. Instead, efforts were often initiated by single actors that act in accordance with their own vision for circular construction (Coenen et al., 2022b). Several of these efforts are now nevertheless considered prominent examples of circularity in the sector. The emergence of these alternative problem framings and the success of alternative solutions (e.g., bio-based materials and the reuse of building components) highlight the contested nature of the Dutch circular construction sector and reinforces the need for a more reflexive governance. However, this observation does not necessarily inform us about what problem-solution imaginaries exist and how they relate to each other.

3.2. *Identifying imaginaries using Q-methodology*

Q-methodology is an approach that helps understand an individual's subjectivity in relation to inter-subjectivity (Brown, 1982; Stephenson, 1935). The method has roots that stretch back to the early 20th century and has been used in numerous fields to identify, describe, and compare views on topics of interest (e.g., Davies and Hodge, 2007; Gruszka, 2017; Rajé, 2007; Wolsink and Breukers, 2010). Scholars recently underlined Q-methodology's potential, but limited uptake, in the context of transitions (Hansmeier et al., 2021). Some transition studies have already used the method to study inter-subjectivity (e.g., perspectives, imagined publics) related to solutions like carbon taxes (Mehleb et al., 2021), electric vehicles (Lee and Park, 2023), resource management (Gruber, 2011; Kügerl et al., 2023; Streit et al., 2023), and biomass/gas (Bauer, 2018; Cuppen et al., 2010; Rodhouse et al., 2021; Silaen et al., 2020).

This paper applies Q-methodology to identify, describe, and compare divergent imaginaries specifically in relation to the problem-solution space. Q-methodology is suitable for this purpose for at least four reasons. First, imaginaries are understood as "collectively held … vision[s] of desirable futures" (Jasanoff and Kim, 2015, p. 5). Q-methodology is specifically designed to derive *collectively held* views from individual ones, and therefore goes beyond alternative research methods like interviews and focus groups. Second, it yields insights into the heterogeneity of these collectively held viewpoints (i.e., the degree of divergence) in contrast to finding the most generalizable viewpoint as commonly done in descriptive statistics. Identifying this heterogeneity is not only crucial for understanding and navigating conflict, but also for the inclusion of minorities' perspectives. Third, it allows the researcher to identify these collectively held views within a debate without predefining groups. The respondents largely determine what shared views emerge from the analysis, reducing researchers' bias (Robbins and Krueger, 2000). Fourth, the collectively held views that emerge from Q-methodology allow for their systematic comparison by using their, so-called, factor arrays – the typical answers for each collectively held view. This systematic comparison contributes to the reproducibility of the approach.

Q-methodology involves six steps that include data collection and data analysis (c.f., Cuppen et al., 2010). The first step concerns

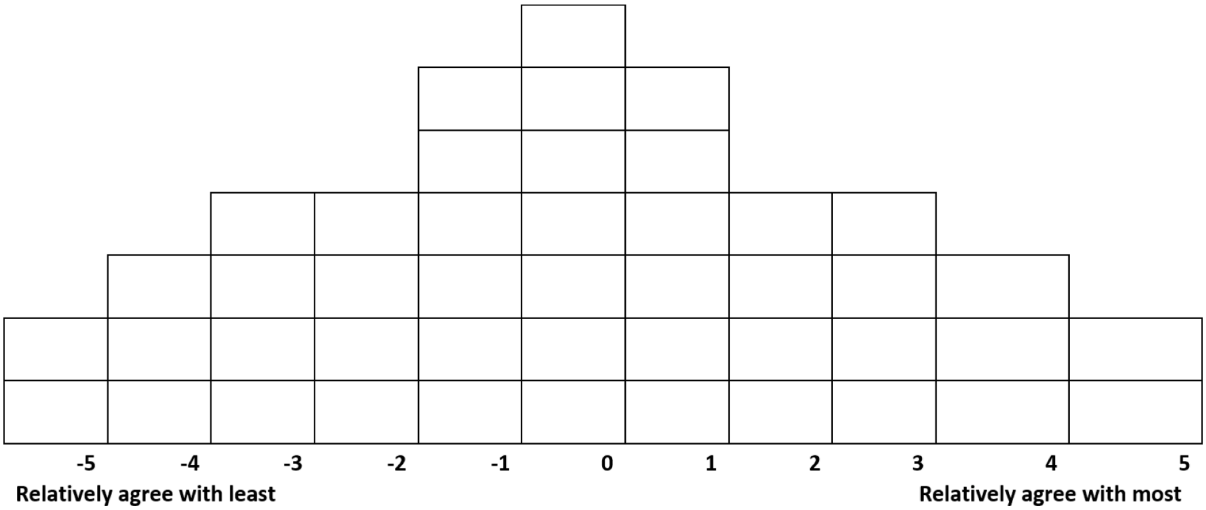

Fig. 2. Q-sort distribution. Source: authors' own elaboration.

taking stock of the 'concourse'. This refers to the wide range of ideas that constitute the topic of interest. In order to identify the variety of views on the problems and solutions vis-a-vis circular construction, this paper adopts data from Coenen et al. (2022a). The data concerns transcripts of approximately 90 min long semi-structured interviews with 20 stakeholders that relate to the imaginary *'Circular construction by 2050'*. These stakeholders were selected through purposive sampling to cover the heterogeneous institutional roles found in innovation systems as described by Kuhlmann and Arnold (2001), such as industrial actors (e.g., contractors, engineering firms), intermediaries (e.g., network organizations, standardization institutes, consultancies), consumers (e.g., construction clients), societal stakeholders (e.g., civil society organizations, representatives), governmental organizations (e.g., ministries), and research institutes (e.g., research institutes and universities). The transcripts are highly relevant as the interviews aimed to identify stakeholders' perspectives on the Dutch circular construction's problem-solution space. Interviewees were specifically asked what they believed were the problems that circular construction addresses, and what the solutions are that could realize circular construction. Interviews were conducted until no new themes emerged (i.e., thematic saturation). Although interviews are not strictly necessary for a Q-methodology, they were used to enhance the validity of our concourse.

The second step aims to distill a manageable set of diverse statements that reflects the heterogeneity of the concourse – hereafter called the 'Q-set'. Deriving statements was done through inductive thematic analysis (Braun et al., 2019; Braun and Clarke, 2006). Transcripts were analyzed using 'open coding' on the sentence level according to two themes: the *problems* that circular construction aims to address (1), and the *solutions* that could realize circular construction (2). For our coding rules we defined problems as "matters that cause one difficulty or need to be dealt with" and defined solutions as "answers to problems". Themes that emerged from 'axial coding' were collectively discussed to resolve any inter-coder disagreements and were each collectively translated into statements. Statements should be unique, clear, and brief. Overlapping statements were omitted or merged. All statements were shared with three stakeholders (i.e., two researchers and one practitioner) to test them for unambiguity. The thematic analysis resulted in 45 statements of which 18 were problem-oriented and 27 solution-oriented (Appendix A).

The third step involves the selection of respondents – i.e., the P-sample. Because Q-methodology aims to reveal the *variety* of perspectives as opposed to reflecting the relative *importance* of perspectives, Q-methodology is usually done through purposive sampling with small sample sizes, as opposed to random sampling with large sample sizes (McKeown and Thomas, 1988). Typical sample sizes range from 20 – 60 respondents (Phi et al., 2014). Moreover, the diversity of respondents' worldviews is crucial for Q-methodology. Purposive sampling therefore aims to include respondents that reflect the broad range of views on a particular topic. These respondents are usually different from those who were interviewed for the concourse (step 1) to enhance the reliability of Q-methodology. To ensure a diverse P-sample, 58 actors were invited by email to partake in this study, and chosen based on their actor type (e.g., industry) and sub-type (e.g., supplier) that they represent (Appendix B). This resulted in 34 respondents.

The fourth step refers to the Q-sort. During the Q-sort, respondents ranked the statements on a Likert-scale according to their vision i.e., −5 to 5 in which −5 represented 'relatively agree with least' and 5 indicated 'relatively agree with most' (Fig. 2). Ranking followed a normal distribution with few statements on each extreme. Q-sorts were digitally sorted and collected using qmethodsoftware.com, which is an online survey platform (Lutfallah and Buchanan, 2019). Respondents entered this survey by emailed invitations. A Pearson correlation matrix of the 34 Q-sorts was created to yield an understanding of the P-sample's diversity. The mean Q-sort correlation is 0.29, suggesting a heterogeneous P-sample in terms of visions for the Dutch circular construction sector.

In the fifth step, a factor analysis is conducted to yield groups (i.e., factors) of highly correlating Q-sorts (i.e., rankings). For Q-methodology, the standard approach is a centroid factor analysis with a Varimax factor rotation (Watts and Stenner, 2005). Factors are typically included if they contain at least one unique factor loading, indicating that at least one respondent's perspective corresponds best with a factor. Furthermore, factors preferably meet both the Kaiser-Guttman criterion and Humphrey's rule.

In this study, factors that emerge from the analysis represent imaginaries with which multiple respondents' visions correlate. We followed the approach described above and included factors with at least one unique factor loading of 0.385 or above, indicating a vision's correlation with a factor at the statistically significant level of $p < 0.01$ (Eq. (1)). This factor loading threshold was computed as follows (McKeown and Thomas, 1988):

$$Factor\ loading = 2.58 * SE = 2.58 * \frac{1}{\sqrt{N\ statements}} \quad (1)$$

The factor analysis resulted in 3 factors (i.e., imaginaries), with which the visions of 30 respondents correlated significantly (Appendix B). It must be noted that a respondent's vision can correlate significantly with multiple factors. To enhance the comprehensibility of the results, we grouped every respondent with the factor that the person correlated best with. 4 respondents did not load significantly on any factor. All factors satisfied both the Kaiser-Guttman criterion and Humphrey's rule. Appendix C and Appendix D provide the factor arrays and factor loadings, respectively.

In the sixth step, these factors are interpreted using several forms of data. The interpretation is largely based on the highest/lowest (+5,+4,−4,−5) and distinguishing statements (Tables 1–3). Distinguishing statements are those that were Q-sorted differently, on the statistically significant level of $p < 0.01$, for one factor in comparison to remaining factors (Coogan and Herrington, 2011; Rodhouse et al., 2021). The nature of statements that followed from step two furthermore inform us about the orientation of factors (i.e., problem-oriented or solution-oriented). We also used the preliminary interview data to contextualize the factors and statement scores. Each factor represents an imaginary regarding the Dutch circular construction sector.

The analysis was extended by comparing these identified imaginaries with the government-constructed imaginary ***'Circular construction by 2050'*** (Section 3.1.) as presented through various policy documents (e.g., BZK, 2019; IenW and EZK, 2016). These policy documents were subject to the same thematic analysis, as described in step two of this section, to understand the explicitly mentioned problem-oriented and solution-oriented views of the government.

4. Results

In what follows, Section 4 describes each imaginary that emerged from the Q-analysis. We have named these three imaginaries ***'We need to use less resources more efficiently'*** (Section 4.1), ***'Let's reimagine design strategies'*** (Section 4.2), and ***'Construction needs a mix of solutions'*** (Section 4.3).

4.1. Imaginary 1: 'We need to use less resources more efficiently'

Respondents that support this imaginary appear to have a defined idea of the problem (Table 1). Circular construction can help avoid resource depletion and contribute to a climate-neutral society. This imaginary disagrees most with the statements that circular construction will reduce the risk of water shortages and will benefit the water quality in the Netherlands. This imaginary unanimously agreed on the insignificancy of circularity for social inequalities. In terms of solutions, it believes that circularity should be achieved through a reduction of primary resources. The actors unanimously agreed on the importance of using resources more efficiently. In addition, this imaginary supports a cradle-to-cradle approach and the minimization of material use. They furthermore doubt that block chain or a change in asset ownership would effectively resolve the problems circular construction aims to address.

17 respondents correlated significantly with this imaginary, of which 13 corresponded best with it. 7 respondents correlated solely on this imaginary. The 13 respondents consisted of actors from the category industry ($N = 2$), construction clients ($N = 4$), researchers ($N = 4$), advisory firms ($N = 2$), and infrastructure ($N = 1$).

4.2. Imaginary 2: 'Let's reimagine design strategies'

Imaginary 2 believes that circular construction helps address resource depletion and achieve a climate-neutral society, and comparatively disagrees that circular construction will combat water shortages, water pollution, social inequalities, and biodiversity loss (Table 2). It appears to fairly disagree that circular construction can and should prioritize waste reduction. In terms of solutions, this imaginary primarily focuses on design strategies. While this group believes downcycling is avoidable, it is not a proponent of recycling as a solution pathway. Instead, design strategies should strive to move material flows as high as possible on the R-ladder (e.g., refuse, rethink, reuse, etc.). Although resource efficiency is deemed important, circular construction should also focus on modular designs and design-for-disassembly. The imaginary pleads for material passports, and new monitoring and measurement systems to provide insight into circularity.

13 respondents correlated significantly, of which 9 corresponded best with this imaginary. 6 respondents correlated solely on this imaginary. The 9 respondents consisted of actors from the category industry ($N = 1$), construction clients ($N = 3$), policy ($N = 1$), researchers ($N = 2$), advisory firms ($N = 1$), and infrastructure ($N = 1$).

4.3. Imaginary 3: 'Construction needs a mix of solutions'

According to imaginary 3, the central problem that circular construction tackles is the overuse of primary resources to prevent resource depletion (Table 3). It relatively disagrees that circular construction could reduce greenhouse gasses and particle emissions. Furthermore, it seems comparatively unconvinced of the potential benefits of circularity in relation to water shortages, water

Table 1
Distinguishing (D) and most defining (+5,+4,−4,−5) problem-oriented (P) and solution-oriented (S) statements.

Distinguishing and defining statements	No.	Statement
+5	5(P)	With circular construction, we avoid the depletion of our earth
+5 (D)	17(P)	Circular construction contributes to achieving a climate-neutral society
+4	23(S)	A reduction in the use of primary resources must be a priority for circular construction
+4	27(S)	Circular construction starts with thinking about how to use resources efficiently
+4 (D)	41(S)	Circular construction will need to focus more on the 'cradle-to-cradle' strategy
+3 (D)	37(S)	In circular initiatives, more focus is needed on sustainable materials
+2 (D)	32(S)	Future circular projects should focus on avoiding material use as much as possible
0 (D)	34(S)	Circular construction requires that assets are designed for disassembly
0 (D)	4(P)	Circular construction addresses the problem of waste production
0 (D)	6(P)	The problem of linear construction lies mainly in the use of primary resources
0 (D)	21(S)	Modular design is essential for circular construction
0 (D)	25(S)	Circular construction requires new monitoring and measurement systems that can be used to manage circularity
−1 (D)	13(P)	Circular construction can reduce the sector's energy consumption
−1 (D)	19(S)	In a circular construction, down cycling of materials is inevitable
−2 (D)	18(P)	Circular construction is primarily a means to reduce greenhouse gas emissions
−2 (D)	35(S)	Material passports are necessary to realize circular construction
−3 (D)	1(P)	Circular construction provides lower particulate emissions than linear construction
−3 (D)	40(S)	Climate adaptive building contributes to achieving circular construction
−3 (D)	30(S)	As-a-service business models play a key role in kick-starting the transition to circular construction
−4	15(P)	Circular construction contributes to reducing social inequalities in our society
−4 (D)	26(S)	In order to realize a circular construction, suppliers and contractors must ultimately become responsible for assets over their entire life cycle
−4 (D)	42(S)	Block chain can play an important role in making circular construction a reality
−5	8(P)	Circular construction reduces the risk of water shortages in the Netherlands
−5	11(P)	Circular construction benefits the water quality of the Netherlands

Table 2
Distinguishing (D) and most defining (+5,+4,−4,−5) problem-oriented (P) and solution-oriented (S) statements.

Distinguishing and defining statements	No.	Statement
+5 (D)	28(S)	Material and design strategies should focus on the highest possible R-strategy on the "R-ladder"
+5	5(P)	With circular construction, we avoid the depletion of our earth
+4	27(S)	Circular construction starts with thinking about how to use resources efficiently
+4	21(S)	Modular design is essential for circular construction
+4	34(S)	Circular construction requires that assets are designed for disassembly
+3 (D)	25(S)	Circular construction requires new monitoring and measurement systems that can be used to manage circularity
+3 (D)	17(P)	Circular construction contributes to achieving a climate-neutral society
+2 (D)	35(S)	Material passports are necessary to realize circular construction
+1 (D)	23(S)	A reduction in the use of primary resources must be a priority for circular construction
0 (D)	39(S)	Circular construction requires substantial changes in current laws and regulations
0 (D)	18(P)	Circular construction is primarily a means to reduce greenhouse gas emissions
−1 (D)	36(S)	New standards and guidelines are needed to facilitate circular construction
−1 (D)	1(P)	Circular construction provides lower particulate emissions than linear construction
−2 (D)	26(S)	In order to realize a circular construction, suppliers and contractors must ultimately become responsible for assets over their entire life cycle
−2 (D)	6(P)	The problem of linear construction lies mainly in the use of primary resources
−3 (D)	8(P)	Circular construction reduces the risk of water shortages in the Netherlands
−3 (D)	33(S)	Circular construction should focus on reducing waste production
−3 (D)	7(P)	Circular construction is necessary to combat the decline of biodiversity
−4	11(P)	Circular construction benefits the water quality of the Netherlands
−4	15(P)	Circular construction contributes to reducing social inequalities in our society
−4 (D)	4(P)	Circular construction addresses the problem of waste production
−5 (D)	19(S)	In a circular construction, down cycling of materials is inevitable
−5 (D)	22(S)	The construction sector must focus on recycling to become circular

Table 3
Distinguishing (D) and most defining (+5,+4,−4,−5) problem-oriented (P) and solution-oriented (S) statements.

Distinguishing and defining statements	No.	Statement
+5 (D)	25(S)	Circular construction requires new monitoring and measurement systems that can be used to manage circularity
+5	23(S)	A reduction in the use of primary resources must be a priority for circular construction
+4	34(S)	Circular construction requires that assets are designed for disassembly
+4	21(S)	Modular design is essential for circular construction
+4 (D)	44(S)	Procurement strategies are essential tools for achieving circular assets
+3 (D)	35(S)	Material passports are necessary to realize circular construction
+1 (D)	6(P)	The problem of linear construction lies mainly in the use of primary resources
+1 (D)	45(S)	Reducing the material demand requires changes in our lives, for example by living smaller
+1 (D)	16(P)	With circular construction, the industry's supply risks of materials and components can be decreased
−1 (D)	31(S)	A carbon tax is a crucial measure to accelerate the transition to a circular construction sector
−1 (D)	2(P)	One of the goals of circularity in the construction industry is to reduce greenhouse gas emissions
−1 (D)	14(P)	The core problem that circular construction addresses is environmental impact and climate change
−2 (D)	17(P)	Circular construction contributes to achieving a climate-neutral society
−2 (D)	4(P)	Circular construction addresses the problem of waste production
−3 (D)	12(P)	Circular construction can prevent health damage by better handling toxic materials
−3 (D)	19(S)	In a circular construction, down cycling of materials is inevitable
−3 (D)	20(S)	Circular construction requires that a large portion of the materials used be bio-based
−3 (D)	26(S)	In order to realize a circular construction, suppliers and contractors must ultimately become responsible for assets over their entire life cycle
−4	11(P)	Circular construction benefits the water quality of the Netherlands
−4 (D)	1(P)	Circular construction provides lower particulate emissions than linear construction
−4 (D)	18(P)	Circular construction is primarily a means to reduce greenhouse gas emissions
−5	15(P)	Circular construction contributes to reducing social inequalities in our society
−5	8(P)	Circular construction reduces the risk of water shortages in the Netherlands

pollution, biodiversity loss, and social inequalities. What sets imaginary 3 apart from other imaginaries is its strong support for a mix of solutions. It advocates material passports, and new monitoring and measurement systems to manage circularity. It also implores changes in procurement strategies and living standards. Imaginary 3 supports novel design strategies such as modular design and design-for-disassembly. A number of these solutions focus on facilitating circularity.

12 respondents correlated significantly, of which 8 corresponded best with this imaginary. 5 respondents correlated solely on this imaginary. The 8 respondents consisted of actors from the category industry ($N = 1$), construction clients ($N = 5$), and advisory firms ($N = 2$). Noteworthy is that nearly half of all actors falling in the category construction clients correlate statistically significantly with this imaginary (6 out of 13).

5. Comparing imaginaries

Section 5.1 proceeds by comparing the three identified imaginaries based on their highest/lowest statements to understand contestation. Section 5.2 follows by comparing these three identified imaginaries with the government-constructed imaginary *'Circular construction by 2050'*.

5.1. Comparing identified imaginaries

This section compares the three imaginaries to understand their differences and similarities. Table 4 provides a correlation matrix of the three imaginaries. Both the correlation matrix and the descriptions above suggest room for common ground as they share various normative ideas. For example, all imaginaries agree that circular construction could address the problem of resource depletion of (primary) resources by increasing efficiency. All imaginaries seem to relatively disagree with the idea that asset ownership should be shifted from public organizations to suppliers and contractors. In addition, all imaginaries seem to disagree that circular construction addresses water pollution, water shortages, and social inequalities. Hence, all imaginaries seem skeptical about some potential socio-environmental benefits of circular construction. The mean Likert-scale ranking of the problem-oriented statements and solution-oriented statements (Table 5) suggest furthermore that imaginary 3 *'Construction needs a mix of solutions'* agrees more with the solution statements and less with the problem statements than the other imaginaries.

Imaginary 2 *'Let's reimagine design strategies'* and imaginary 3 *'Construction needs a mix of solutions'* are most similar ($r = 0.65$). Actors from both these groups tend to support modular designs, design-for-disassembly, material passports, and new monitoring and measurements systems. They believe that down cycling is preventable. However, these imaginaries relatively disagree on the importance of circular construction for climate-neutrality. Imaginary 3 furthermore disagrees that circular construction reduces greenhouse gas and particulate emissions. Imaginary 2 also differs from imaginary 3 in the sense that imaginary 3 appears less confident about the problems that circular construction addresses.

Imaginary 1 *'We need to use less resources more efficiently'* and imaginary 2 *'Let's reimagine design strategies'* ($r = 0.60$) both believe that circular construction will contribute to climate-neutrality, and that it must prioritize efficient resource use. Yet, imaginary 2 seems to be a greater proponent of closed systems while imaginary 1 emphasizes the reduction of material flows.

Imaginary 1 *'We need to use less resources more efficiently'* and imaginary 3 *'Construction needs a mix of solutions'* are the least similar imaginaries ($r = 0.57$). Both imaginaries relatively disagree with the idea that suppliers and contractors should be responsible for assets throughout their life cycle. These two imaginaries also believe that circular construction will not lower greenhouse gas emissions and particulate emissions. While imaginary 3 predominantly focuses on solutions, imaginary 1 demonstrates a more balanced view, focusing on both problems and solutions. Imaginary 3 supports a plurality of solutions, advocating modular designs, design-for-disassembly, novel procurement strategies, material passports, and new monitoring and measurement systems. Imaginary 1 signifies a more narrow solution space, prioritizing efficient resource use, sustainable material, and cradle-to-cradle strategies.

Lastly, the actor types from our P-sample appear fairly evenly distributed among imaginaries (Table 6). The only actor type that is disproportionally distributed are researchers. Most researchers are adherents of the first ($N = 4$) and second imaginary ($N = 2$), but none support the third imaginary ($N = 0$). This suggests that the normative visions of circular construction are largely independent of the actor type.

5.2. Comparing identified imaginaries with the *'Circular construction by 2050'* imaginary

Our results indicate that the three imaginaries differ in the extent to which they acknowledge and favor certain problems and solutions. These imaginaries coexist with the imaginary *'Circular construction by 2050'* as constructed by the Dutch government, and actualized through its formal policy (BZK, 2019; IenW and EZK, 2016). While it is increasingly recognized that imaginaries may clash (Burnham et al., 2017; Hess, 2015), we identify and describe the problems/solutions that various imaginaries disagree on. We

Table 4
Pearson correlation matrix between imaginaries.

	Imaginary 1	Imaginary 2	Imaginary 3
Imaginary 1	1.00	0.60	0.57
Imaginary 2	0.60	1.00	0.65
Imaginary 3	0.57	0.65	1.00

Table 5
Mean ranking of problem-oriented statements and solution-oriented statements per imaginary on a Likert-scale of +5 to −5.

	Mean ranking problem-oriented statements	Mean ranking solution-oriented statements
Imaginary 1	−0.61	0.41
Imaginary 2	−0.61	0.41
Imaginary 3	−1.50	1.00

Table 6
Number of actors with highest significant loading per imaginary. Note: actors with non-significant loadings are not included.

	Industry	Construction clients	Policy	Researchers	Advisory firms	Infrastructure	Total
Imaginary 1	2 (40%)	4 (33%)	0 (0%)	4 (67%)	2 (40%)	1 (50%)	13 (38%)
Imaginary 2	1 (20%)	3 (25%)	1 (100%)	2 (33%)	1 (20%)	1 (50%)	9 (26%)
Imaginary 3	1 (20%)	5 (42%)	0 (0%	0 (0%)	2 (40%)	0 (0%)	8 (24%)
Total	5 (100%)	12 (100%)	1 (100%)	6 (100%)	5 (100%)	2 (100%)	30 (100%)

furthermore reveal spaces for common ground that could foster a collective response. These differences and commonalities inform us about how policymakers can possibly move forward.

When focusing on common grounds, all three identified imaginaries seem to agree with the '*Circular construction by 2050*′ imaginary that circular construction could address the depletion of (primary) resources by focusing on their efficient use. Similar to the three identified imaginaries, the *'Circular construction by 2050*′ imaginary does not target water pollution, water shortages, and social inequality. This opposes several perspectives derived from the concourse interviews (Section 3.2, step 1). Especially one interviewee from the Dutch Union of Water boards envisioned that circular construction would result in these benefits. However, our results suggest that this vision is not widely shared. The *'Circular construction by 2050*′ furthermore stresses the importance of both material passports and new measurement and monitoring systems. While this vision resonates with that of imaginary 2 and 3, it is considered less important in imaginary 1.

In terms of contestation, imaginary 1 and 3 both seem skeptical that circular construction will lower greenhouse gas emissions. This fundamentally contradicts the *'Circular construction by 2050*′ imaginary in which CO_2 reduction forms one of the main rationales for circular construction (BZK, 2019; IenW and EZK, 2016). In addition, a very clear solution priority for imaginary 2 and 3 – and in a lesser extent for imaginary 1 – is the use of modular designs and design-for-disassembly. Yet, this is hardly mentioned by the strategy rapports that delineate the government's imaginary. The *'Circular construction by 2050*′ imaginary also pleads for more regulation and standardization of circular construction, but the other imaginaries seem less outspoken about such approaches. The same can be argued for climate adaptive approaches to construction. While the government supports this solution pathway, other imaginaries are less outspoken about it.

Hence, the results indicate that there is not merely disagreement among the three identified imaginaries, but also between these and the *'Circular construction by 2050*′ imaginary. Regardless of the *de facto* existence and severity of the sector's CO_2 emissions, it seems unlikely that actors from the three identified imaginaries will be mobilized by this framing. Policymakers could, on the contrary, gain support from the three imaginaries by incorporating modular designs and design-for-disassembly as solution strategies. Policymakers could reframe problems/solutions accordingly to redirect patterns of innovation in response to the societal challenges.

6. Discussion

In what follows, Section 6.1 reflects on the implications of this paper. Section 6.2 proceeds by discussing how policymakers can navigate contested problem-solution spaces, and thus offers ways forward. Section 6.3 expands on some limitations and opportunities for future research, which is followed by concluding remarks in Section 6.4.

6.1. Operationalizing problem-solution spaces with Q-methodology

This paper demonstrated how contestation in the problem-solution space can be operationalized through Q-methodology using various types of sources: by combining and comparing data of interviews, a survey, and policy documents. Accordingly, we illustrate how divergent imaginaries can be identified, described, and compared to understand the way and extent to which challenges are contested. Although Q-methodology has been used to understand contestation before (e.g., Cuppen et al., 2010; Gruszka, 2017; Ligtvoet et al., 2016; Rodhouse et al., 2021), our contribution lays in offering a systematic approach to deconstruct contestation in terms of problem-oriented and solution-oriented disagreement. By differentiating these two spaces, researchers and practitioners can scrutinize one of these two parts further. In our illustrative case, for instance, the mean rankings (Table 5) indicate that the Dutch circular construction sector is more convergent in the solution space than in the problem space – particularly in imaginary 3. This suggests circular construction to be a "solution in search of a problem" (Wanzenböck et al., 2020, p. 478). Actors could subsequently examine in more depth why the problem space is contested (e.g., information asymmetries or incompatible value-systems) so that actors can further consolidate a shared understanding of circular construction's problem space. The operationalization of this paper thus helps advance research on problem-solution spaces, and helps actors analyze and navigate the contestation of any given societal challenge.

6.2. Policy implications: navigating contestation

The operationalization of the problem-solution space by means of Q-methodology has various implications for policy. Because policymakers increasingly deploy challenge-led policies to create shared understandings and mobilize stakeholders into a uniform direction (Hekkert et al., 2020; Mazzucato, 2018, 2017), learning from diverse and conflicting worldviews is required to avoid transformational failures (Schot and Steinmueller, 2018; Weber and Rohracher, 2012). Without a reflexive governance (Voß and Bornemann, 2011), policymakers may acquire the false impression that views on problems and solutions are widely shared (Wanzenböck et al., 2020). The operationalization of the problem-solution space is not merely a reflexive exercise for policymakers, but it also stimulates participants of the Q-study to reflect on problems and potential solutions that could be taken for granted.

Disagreement prompts the question of how contestation should be navigated. We argue that our reflexive exercise contributes to *constructive approaches* (Cuppen, 2012; Ligtvoet et al., 2016) by yielding insights that could enhance mutual understanding necessary to find common ground, establish compromises, or reframe problems and solutions. In our case, such an approach could lead to more support for modular designs and design-for-disassembly. While this is promising, mutual understanding is insufficient for overcoming disagreements that are rooted in fundamentally incompatible values and worldviews (Blok and Lemmens, 2015; Schon and Rein, 1994). Impasses are preferably avoided as not acting may be seen as the prioritization of one imaginary over the other. What is more, reflexivity on the normative divergence in the problem-solution space does not necessarily inform policymakers about the epistemological nature of problems and solutions (e.g., what solutions are *de facto* effective?). For example, stakeholders can disagree about the necessary 'radicality' of solution pathways. While some transformations require 'small wins' and/or short-term solutions, others would benefit from radical and/or long-term ones (Bours et al., 2021; Termeer and Dewulf, 2019). A default approach for policymakers is to rely on evidence-based visions of scientific experts. Yet, this is problematic for the reason that researchers can likewise hold divergent views as we show in our illustrative case. In addition, the input of other actors should not be disregarded because they have a qualitatively different, but complementary, expertise through experience. Such *experts by experience* are confronted with the problem, and are crucial for the implementation of solutions (Wanzenböck and Frenken, 2020). When contestation is rooted in incompatible values and worldviews, and exacerbated by epistemic uncertainty, policymaking tends to be highly problematic.

To deal with this, scholars recently suggested that *agonistic approaches* may offer a way out. According to this approach, decisions are made while recognizing that fundamental disagreements are inevitable (Popa et al., 2021; Scott, 2021). In practice this means that policymakers need to make difficult decisions while acknowledging opposing imaginaries as rational (Mouffe, 2000). In our particular case, the three imaginaries could fundamentally disagree whether CO_2 emissions are problematic. An agonistic approach could then be to accept this worldview's incompatibility with the *'Circular construction by 2050'* imaginary, but to still demand a reduction of CO_2 emissions on epistemological grounds. The operationalization of the problem-solution space through Q-methodology is instrumental to revealing the source of disagreement, and thus helps understand whether a constructive or agonistic approach is more suitable.

6.3. Limitations and future research

We demonstrate an operationalization of the problem-solution space by means of Q-methodology. While Q-methodology is a broadly accepted research method that has existed already for nearly a century, it is important to stress a number of limitations (Brown, 1992; Stephenson, 1935). First, Q-methodology relies on statements that usually emerge from thematic analyses. While thematic analysis is a useful research method for identifying key aspects of large data sets, its methodological flexibility can lead to inconsistencies that affect the reproducibility of themes – in our case the problem and solution-oriented statements (Nowell et al., 2017). This is especially relevant for wicked problems research in which problem framings and solution framings interact in the sense that the framing of one may suggest the framing of the other. One should furthermore be aware of potential biases that emerged from the sampling strategies. Although we aimed to include actors across all actor types in our P-sample, no civil society organization was willing to partake in this study. Our results therefore hint that our mission-specific innovation system is distinct from many other systems in the sense that societal stakeholders have relatively little interest in its mission. Second, statistical studies of qualitative materials tend to treat quantitative results as 'real'. They are often objectified and reified. We would like to stress that our results and the underlying data (i.e., interviews, survey, and policy documents) are constructs. Our study may therefore come with epistemological limitations. For instance, notions like 'circular construction' may suffer from interpretative flexibility (Pinch and Bijker, 1984). Results should therefore be treated with caution.

Our study offers various avenues of future research. First, it examined contestation in a problem-solution space by identifying, describing, and comparing underlying conflicting imaginaries by using Q-methodology. Although this method is useful for identifying the variety of imaginaries, it does not yield an understanding of their ubiquity. A promising continuation of our operationalization would be to conduct large scale surveys that aim to understand the generalizability of imaginaries that were identified. Second, while Jasanoff & Kim (2009) argue that collectively held visions help understand socio-technical developments, our results suggest that various actors who hold power and agency have distinct visions that do not fit in dominant imaginaries. Considering the performative nature of these uncommon visions, future research could study such outliers when exploring futures. Third, both a strength and limitations of the problem-solution space is that it reduces the complex phenomenon of contestation to perspectives on problems and solutions. While this simplification provides an initial understanding of contestation, problem-solution spaces are situated in a wider socio-technical and path-dependent system in which worldviews are driven by underlying values. It would be valuable to examine these broader contexts, historical dimensions, and value systems from which imaginaries emerge. For example, a better appreciation of the values at play would help understand whether either constructive or agonistic approaches are more appropriate. Fourth, this study provides a snapshot of a contested problem-solution space. Yet, imaginaries change over time. Capturing their temporal nature would therefore provide insight into the dynamics of imaginaries and societal challenges. We speculate, for example, that imaginaries may either drift apart or move closer to each other – causing polarization or unification. Apart from gaining a deeper understanding, such an approach would provide useful insights for developing policy instruments aimed at problem-solution convergence. Fifth, our operationalization is applied to the circular construction sector. Future applications of other problem-solution spaces would provide more insight into the usefulness of the approach.

6.4. Concluding remarks

This study contributes to the literature on problem-solution spaces and reflexive governance by offering an operationalization that identifies, describes, and compares conflicting imaginaries of wicked problems and potential solutions by means of Q-methodology. To demonstrate this operationalization, we applied the approach to the case of the Dutch circular construction and identify divergent imaginaries that coexist with the government-constructed imaginary *'Circular construction by 2050'*. This study identified three imaginaries that help us understand contestation. We named these imaginaries (1) '*We need to use less resources more efficiently',* (2) *'Let's reimagine design strategies'*, and (3) *'Construction needs a mix of solutions'*. We revealed various (dis)agreements between the imaginaries and diagnosed circular construction as a 'solution in search of a problem'. Operationalizing contested problem-solution spaces prompts the questions of how to navigate disagreement. This paper discusses how constructive and agonistic approaches may offer ways forward to shape a collective response. While this study explores and links the notions of imaginaries, contestation, and problem-solution spaces, we advocate future research that helps us further understand how to arrive at a shared understanding of both societal problems and their required solutions. This would help actors more effectively address the societal challenges of our time.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The authors do not have permission to share data.

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Appendix A. – Q-statements

	No.	Statements
Problem-oriented	1	Circular construction provides lower particulate emissions than linear construction
	2	One of the goals of circularity in the construction industry is to reduce greenhouse gas emissions
	3	Circularity has the potential to contribute greatly to solving the nitrogen crisis in construction
	4	Circular construction addresses the problem of waste production
	5	With circular construction, we avoid the depletion of our earth
	6	The problem of linear construction lies mainly in the use of primary resources
	7	Circular construction is necessary to combat the decline of biodiversity
	8	Circular construction reduces the risk of water shortages in the Netherlands
	9	Circular construction helps reduce CO2 emissions to meet the Netherlands' climate goals
	10	With circular construction, we can reduce unnecessary material losses in the supply chain
	11	Circular construction benefits the water quality of the Netherlands
	12	Circular construction can prevent health damage by better handling toxic materials
	13	Circular construction can reduce the sector's energy consumption
	14	The core problem that circular construction addresses is environmental impact and climate change
	15	Circular construction contributes to reducing social inequalities in our society
	16	With circular construction, the industry's supply risks of materials and components can be decreased
	17	Circular construction contributes to achieving a climate-neutral society

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	No.	Statements
	18	Circular construction is primarily a means to reduce greenhouse gas emissions
Solution-oriented	19	In a circular construction, down cycling of materials is inevitable
	20	Circular construction requires that a large portion of the materials used be bio-based
	21	Modular design is essential for circular construction
	22	The construction sector must focus on recycling to become circular
	23	A reduction in the use of primary resources must be a priority for circular construction
	24	The construction sector must commit to reusing components to become circular
	25	Circular construction requires new monitoring and measurement systems that can be used to manage circularity
	26	In order to realize a circular construction, suppliers and contractors must ultimately become responsible for assets over their entire life cycle
	27	Circular construction starts with thinking about how to use resources efficiently
	28	Material and design strategies should focus on the highest possible R-strategy on the "R-ladder
	29	Circular construction must focus primarily on extending the life of assets
	30	As-a-service business models play a key role in kick-starting the transition to circular construction
	31	A carbon tax is a crucial measure to accelerate the transition to a circular construction sector
	32	Future circular projects should focus on avoiding material use as much as possible
	33	Circular construction should focus on reducing waste production
	34	Circular construction requires that assets are designed for disassembly
	35	Material passports are necessary to realize circular construction
	36	New standards and guidelines are needed to facilitate circular construction
	37	In circular initiatives, more focus is needed on sustainable materials
	38	Circular construction should establish residual value based on the actual physical condition of assets rather than their depreciation period
	39	Circular construction requires substantial changes in current laws and regulations
	40	Climate adaptive building contributes to achieving circular construction
	41	Circular construction will need to focus more on the 'cradle-to-cradle' strategy
	42	Block chain can play an important role in making circular construction a reality
	43	A circular construction sector will have to strive to upcycle materials
	44	Procurement strategies are essential tools for achieving circular assets
	45	Reducing the material demand requires changes in our lives, for example by living smaller

Appendix B. – List of respondents

List of respondents, including their actor (sub-)type and statistically significant factor loadings. 'No flag' denotes significant correlations of respondents with imaginaries other than their most fitting imaginary.

No.	Significant factor loading	Actor type	Sub-type	Job description of respondent
R1	1	Industry	Contractor	Department head sustainability
R2	1, 3 (no flag)	Industry	Contractor	Project manager sustainability
R3	2	Industry	Contractor	Chief commercial officer
R4	–	Industry	Supplier	Consultant
R5	3	Industry	Supplier	Manager
R6	3, 1 (no flag)	Construction clients	Public commissioner	Innovation consultant infrastructure
R7	3	Construction clients	Public commissioner	Consultant circular economy
R8	–	Construction clients	Public commissioner	Senior consultant circular economy
R9	1	Construction clients	Public commissioner	Technical manager
R10	3, 2 (no flag)	Construction clients	Public commissioner	Head of district
R11	1	Construction clients	Public commissioner	Senior consultant circular economy
R12	2	Construction clients	Public commissioner	Senior consultant circular economy
R13	3	Construction clients	Public commissioner	Asset manager
R14	2, 1 (no flag)	Construction clients	Public commissioner	Coordinator sustainability
R15	3,2 (no flag)	Construction clients	Public commissioner	Sustainability monitoring
R16	1	Construction clients	Public commissioner	Sustainability consultant
R17	1, 3(no flag)	Construction clients	Public commissioner	Transition director circular public spaces
R18	2	Construction clients	Public commissioner	Ambassador circularity
R19	2,1 (no flag)	Policy	Policymaker	Program secretary
R20	2	Researchers	University	PhD candidate circular construction
R21	1, 2 (no flag)	Researchers	University	PhD candidate circular construction
R22	1, 2 (no flag)	Researchers	University	Full professor
R23	1,3 (no flag)	Researchers	University	Assistant professor circular construction
R24	2, 1 (no flag), 3 (no flag)	Researchers	University	PhD candidate circular infrastructure
R25	1	Researchers	Research institute	Procurement expert dredging technology
R26	1	Advisory firms	Engineering firm	Lead engineer
R27	–	Advisory firms	Engineering firm	Director circular and bio-based solutions
R28	1, 3 (no flag)	Advisory firms	Engineering firm	Architect

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No.	Significant factor loading	Actor type	Sub-type	Job description of respondent
R29	3	Advisory firms	Engineering firm	Business director circular economy
R30	3	Advisory firms	Engineering firm	Circular design manager
R31	2	Advisory firms	Consultancy	Consultant
R32	1	Infrastructure	Networks	Consultant sustainable construction
R33	2	Infrastructure	Networks	Manager
R34	–	Infrastructure	Banking	Business developer circularity

Appendix C. – Factor arrays

	No.	Statements	Factor 1	Factor 2	Factor 3
Problem-oriented	1	Circular construction provides lower particulate emissions than linear construction	−3	−1	−4
	2	One of the goals of circularity in the construction industry is to reduce greenhouse gas emissions	1	0	−1
	3	Circularity has the potential to contribute greatly to solving the nitrogen crisis in construction	−3	−2	−1
	4	Circular construction addresses the problem of waste production	0	−4	−2
	5	With circular construction, we avoid the depletion of our earth	5	5	3
	6	The problem of linear construction lies mainly in the use of primary resources	0	−2	1
	7	Circular construction is necessary to combat the decline of biodiversity	−2	−3	−2
	8	Circular construction reduces the risk of water shortages in the Netherlands	−5	−3	−5
	9	Circular construction helps reduce CO2 emissions to meet the Netherlands' climate goals	1	2	0
	10	With circular construction, we can reduce unnecessary material losses in the supply chain	1	1	2
	11	Circular construction benefits the water quality of the Netherlands	−5	−4	−4
	12	Circular construction can prevent health damage by better handling toxic materials	−1	−1	−3
	13	Circular construction can reduce the sector's energy consumption	−1	0	0
	14	The core problem that circular construction addresses is environmental impact and climate change	3	3	−1
	15	Circular construction contributes to reducing social inequalities in our society	−4	−4	−5
	16	With circular construction, the industry's supply risks of materials and components can be decreased	−1	−1	1
	17	Circular construction contributes to achieving a climate-neutral society	5	3	−2
	18	Circular construction is primarily a means to reduce greenhouse gas emissions	−2	0	−4
Solution-oriented	19	In a circular construction, down cycling of materials is inevitable	−1	−5	−3
	20	Circular construction requires that a large portion of the materials used be bio-based	−1	0	−3
	21	Modular design is essential for circular construction	0	4	4
	22	The construction sector must focus on recycling to become circular	−2	−5	−2
	23	A reduction in the use of primary resources must be a priority for circular construction	4	1	5
	24	The construction sector must commit to reusing components to become circular	1	3	3
	25	Circular construction requires new monitoring and measurement systems that can be used to manage circularity	0	3	5
	26	In order to realize a circular construction, suppliers and contractors must ultimately become responsible for assets over their entire life cycle	−4	−2	−3
	27	Circular construction starts with thinking about how to use resources efficiently	4	4	2
	28	Material and design strategies should focus on the highest possible R-strategy on the "R-ladder	3	5	1
	29	Circular construction must focus primarily on extending the life of assets	1	1	0
	30	As-a-service business models play a key role in kick-starting the transition to circular construction	−3	0	0
	31	A carbon tax is a crucial measure to accelerate the transition to a circular construction sector	0	2	−1
	32	Future circular projects should focus on avoiding material use as much as possible	2	1	0
	33	Circular construction should focus on reducing waste production	2	−3	1
	34	Circular construction requires that assets are designed for disassembly	0	4	4
	35	Material passports are necessary to realize circular construction	−2	2	3
	36	New standards and guidelines are needed to facilitate circular construction	2	−1	2
	37	In circular initiatives, more focus is needed on sustainable materials	3	−1	0
	38	Circular construction should establish residual value based on the actual physical condition of assets rather than their depreciation period	3	1	3
	39	Circular construction requires substantial changes in current laws and regulations	1	0	2
	40	Climate adaptive building contributes to achieving circular construction	−3	−3	−1
	41	Circular construction will need to focus more on the 'cradle-to-cradle' strategy	4	0	0
	42	Block chain can play an important role in making circular construction a reality	−4	−2	−1
	43	A circular construction sector will have to strive to upcycle materials	2	1	1
	44	Procurement strategies are essential tools for achieving circular assets	0	2	4
	45	Reducing the material demand requires changes in our lives, for example by living smaller	−1	−1	1

Appendix D. – Factor loadings

Factor loadings of respondents per factor. (X) denotes a respondents highest statistically significant factor loading.

No.	Factor 1	Factor 2	Factor 3	Actor type	Sub-type
R1	0.55151 (X)	0.22275	0.33380	Industry	Contractor
R2	0.54937 (X)	−0.03046	0.40704	Industry	Contractor
R3	−0.05025	0.48709 (X)	0.27687	Industry	Contractor
R4	0.30169	0.01773	0.13445	Industry	Supplier
R5	0.07233	0.12408	0.56173 (X)	Industry	Supplier
R6	0.42533	0.22807	0.59774 (X)	Construction clients	Public commissioner
R7	−0.08084	0.09090	0.45189 (X)	Construction clients	Public commissioner
R8	0.25379	0.36412	0.33996	Construction clients	Public commissioner
R9	0.63375 (X)	0.16557	0.02567	Construction clients	Public commissioner
R10	−0.00866	0.53135	0.54385 (X)	Construction clients	Public commissioner
R11	0.39299 (X)	0.27490	0.22987	Construction clients	Public commissioner
R12	0.23892	0.65721 (X)	0.27360	Construction clients	Public commissioner
R13	0.26348	0.06243	0.62832 (X)	Construction clients	Public commissioner
R14	0.39348	0.43647 (X)	0.12564	Construction clients	Public commissioner
R15	0.24948	0.38568	0.46627 (X)	Construction clients	Public commissioner
R16	0.65541 (X)	0.01612	0.18343	Construction clients	Public commissioner
R17	0.49496 (X)	0.24586	0.48728	Construction clients	Public commissioner
R18	0.19378	0.61395 (X)	0.07042	Construction clients	Public commissioner
R19	0.43198	0.56330 (X)	0.33155	Policy	Policymaker
R20	0.35224	0.59180 (X)	0.13472	Researchers	University
R21	0.55424 (X)	0.48054	0.00560	Researchers	University
R22	0.55052 (X)	0.40306	0.10487	Researchers	University
R23	0.53711 (X)	0.03574	0.41175	Researchers	University
R24	0.47150	0.50222 (X)	0.40131	Researchers	University
R25	0.60337 (X)	0.18742	0.24264	Researchers	Research institute
R26	0.66228 (X)	0.13766	0.08904	Advisory firms	Engineering firm
R27	−0.09326	0.18549	−0.0236	Advisory firms	Engineering firm
R28	0.54702 (X)	0.11916	0.48511	Advisory firms	Engineering firm
R29	0.20635	0.35942	0.48966 (X)	Advisory firms	Engineering firm
R30	0.28114	0.38166	0.41516 (X)	Advisory firms	Engineering firm
R31	0.21067	0.47160 (X)	0.23214	Advisory firms	Consultancy
R32	0.58548 (X)	0.10489	−0.18248	Infrastructure	Networks
R33	0.06040	0.53825 (X)	0.11735	Infrastructure	Networks
R34	0.37597	0.37512	0.02973	Infrastructure	Banking

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