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ABSTRACT

Current societal challenges demand enduring engagement and the implementation of innovations. Unfortunately, the project-based nature of the construction industry fails to offer suitable conditions for innovation and change in terms of building long-term relationships and aligning incentives beyond the project scope. In this paper, we explore the potential of an innovation ecosystem perspective to reach sector-wide goals related to societal challenges in the infrastructure sector. Accordingly, five Dutch infrastructure cases were studied in terms of four characteristics: (1) actor heterogeneity; (2) strategic alignment of actors; (3) alignment with respect to a value proposition; and (4) governance structure. We found that the innovation ecosystem perspective has the potential to contribute to innovation in the sector, especially when specific innovations or knowledge building are pursued. In particular, the long-term perspective to collaboration in relation to addressing societal challenges and the shift to more relational ways of governance were found promising avenues for incorporation in the industry. The innovation ecosystem perspective in infrastructure, however, also poses substantial organizational, cultural, and processual challenges, such as adopting novel practices with respect to collaboration and establishing continuing informal relationships beyond the public procurement context.

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Innovation ecosystem; interorganizational relationships; infrastructure sector; project-transcending innovation; industry change

Introduction

Project-based sectors such as the construction industry struggle with the temporal complexities that hamper collaborative action in response to societal challenges (Hilbolling et al. 2021). Especially the traditional, project-based management approaches do not seem to accommodate the changes needed to scale up innovations and move towards higher levels of change (Martinsuo and Hoverfält 2018). Existing approaches insufficiently exploit the benefits of interacting across projects collaboratively and over time (Bygballe and Ingemansson 2011). Melander and Pazirandeh (2019) even claim that a systemic transformation of the construction sector is needed, implying a reconsideration of relationships and activities within and beyond the traditional construction supply chains towards a more collaborative approach.

Construction management scholars increasingly explore novel approaches to overcome the issues of temporality that hinder innovation and collaboration in a project-based environment. Some of these approaches focus on supply chain integration (Kesidou and Sovacool 2019), while others look at collections of parallel and sequential projects under the heading of project ecologies (Hedborg et al. 2020), public-private partnerships (Carbonara and Pellegrino 2020) or collaborative procurement delivery models such as early contractor involvement and alliancing (Hällström et al. 2021). However, these approaches do not offer the conditions required for multiparty innovation towards goals that lay beyond the benefits of single projects, such as climate change and circular economy.

In this paper, we aim to explore the organizational innovation ecosystem perspective to address the issues of temporality and fragmentation in relation to collaboration in the infrastructure sector. In doing so, we follow the suggestion of Volker (2018, p. 20) to “look outside the frames we are familiar with” and make use of concepts that originate from other...
research fields in studying fundamental issues related to construction management. We use the innovation ecosystem concept as a lens to increase our understanding of the implications of collaboration beyond single projects and innovation processes in a construction setting.

The innovation ecosystem perspective has been widely applied in the literature on organizing innovation in industrial sectors and offers a broad perspective that is not limited to dyadic relationships and existing ties between actors (Ritala et al. 2013). Instead, it focuses on aligning the actors in a venture towards a shared value proposition to be realized (Shipilov and Gawer 2020). Innovation ecosystems comprise constellations of actors and flows of value, information and resources that reach beyond single endeavours and niche innovations, and accordingly provide inherently a network perspective (Pel et al. 2020).

Apart from a few studies in construction related to single large projects or networks (e.g. Davies et al. 2014, Pulkka et al. 2016, Pelton et al. 2017), the innovation ecosystem perspective has, to our knowledge, not yet been studied systematically to reveal its potential for cross-project innovation in the specific context of infrastructure projects, such as the development and maintenance of bridges, tunnels and roads. Therefore, the aim of this paper is to explore the potential of adopting an innovation ecosystem perspective in the infrastructure sector. We pay specific attention to the ability to overcome complexities related to the temporariness of collaborative relations that stem from the project-based structure of this sector. As such, we aim to offer an alternative view to collaboration for project-transcending innovation that equips the sector with a starting point to address the emerging societal challenges that go beyond the aims of single projects.

First, we introduce the innovation ecosystem concept, followed by a discussion of the structure of the infrastructure sector and its struggles with respect to addressing project-transcending goals and innovations. Next, we build on this innovation ecosystem perspective by creating a conceptual framework to analyse cases in the infrastructure sector. We apply this framework to five cases in the Netherlands and analyse those in relation to the overall potential of the innovation ecosystem perspective. Finally, we present a discussion and conclusion. Here, we present implications for infrastructure practice and construction management research and, based on the case results, provide suggestions for further research on overcoming the barriers to project-transcending innovation and collaboration in the infrastructure sector and beyond.

**The innovation ecosystem perspective**

In this paper, we adopt an analytical approach to ecosystems and use it as a perspective to rethink the infrastructure system in relation to change and innovation. As such, we exploit its ability to reveal complexities related to the temporariness of relations and collaboration that stem from the project-based structure (e.g. Vargo et al. 2020). Since the late 1990s, the ecosystem perspective has been recognized as a way to understand organizational systems by emphasizing the interactions between system elements and their context (Tsujimoto et al. 2018). In this section we introduce the main theoretical principles of the innovation ecosystem concept to set the ground for application of the innovation ecosystem perspective to the infrastructure sector.

**Ecosystem types**

Despite the wide varieties of ecosystems in literature, the most researched types of ecosystems used in management literature are innovation ecosystems, business ecosystems and platform ecosystems (Jacobides et al. 2018). Whereas innovation ecosystems aim for value creation, business ecosystems aim for value capture (Gomes et al. 2018). Because of this focus on value capture, business ecosystems include the end user for which a network of companies collaborates to address the end user’s needs (Clarysse et al. 2014). Platform ecosystems, contrarily, are characterized by a central platform which connects organizations via shared technologies or standards (Jacobides et al. 2018). Here, complementors can create particular complements that enhance the platform its value offering (Thomas and Autio 2020), and gain access to the platform its customers, e.g. in videogame development (Ozalp et al. 2018). Innovation ecosystems generally entail development and innovation activities characterized by a high level of interdependence and co-creation of value (Ketonen-Oksi and Valkokari 2019). Because of the focus on achieving change and innovation, we specifically adopt the concept of innovation ecosystems in our study to look at project-transcending structures that stimulate sector-wide collaboration and innovations.
Conceptualizing the innovation ecosystem

Innovation ecosystems are constructed around central value propositions (Ritala and Almanopoulou 2017), which are described by Adner (2016) as promises or visions of new value that the combined efforts of the actors involved aim to create. This provides a useful perspective to unlock the collaboration required to innovate, because it not only considers formal relations, but also “new possibilities to operationalize the environment” (Gomes et al. 2018, p.42). Actors in this environment include complementors, end-users, research scholars and policymakers, who generally fall outside the scope of both the traditional supply chain and the network perspectives that are applied in construction. Additionally, innovation ecosystems may involve unconventional actors, such as suppliers of technologies, specialized advisers or suppliers of knowledge or products from other sectors. At the same time, the reach goes beyond single projects, formal relations and industry boundaries (Ketonen-Oksi and Valkokari 2019). Consequently, the innovation ecosystem perspective promotes co-creation and enables value to be created beyond what a single firm could achieve on its own (Smorodinskaya et al. 2017).

Innovation ecosystems typically exhibit high levels of actor heterogeneity (Thomas and Autio 2020). They are hence not necessarily limited to sectoral boundaries and might extend to cross-industry networks. System boundaries of innovation ecosystems are defined by a shared purpose, or at least interdependencies among organizations for creating value. Within well-functioning innovation ecosystems, there is a mutual agreement among participants on the positions and activity flows within the system (Adner 2016). This does not only involve the participants’ positions regarding the value proposition, but also the configuration of roles and activities within the system. Nevertheless, the actors, their roles and their interlinkages within the network may change over time, resulting in a dynamic network in which actors coordinate and complement their inputs to the value proposition (Valkokari 2015). The participant heterogeneity displayed by innovation ecosystems is hence broad and transcends the boundary between public and private sectors (Thomas and Autio 2020).

Given the acknowledgement of interdependencies, actors within the innovation ecosystem may entail both collaborative and competitive relationships, which may result in a coopetitive structure (Moore 1993, Bacon et al. 2020). Coopetition can be understood as collaboration between actors that operate in each other’s competitive areas through the alignment of incentives. This creates interdependencies between the organizations involved (Eriksson and Laan 2007). These interdependencies emerge as actors depend on each other’s success with respect to the value proposition and can be viewed from a technological perspective (in case of co-specialization), an economic perspective (when interdependencies occur in capturing financial gains), a cognitive perspective (due to social rules or assumptions), or a combination of these (Adner and Kapoor 2010, Thomas and Autio 2020). To deal with the different types of interdependencies, actors in innovation ecosystems develop strategies to align their innovation and collaboration processes in order to establish their position within the network (Visscher et al. 2021).

The predefined goals for output are defined as value propositions. Innovation ecosystems are centred around one or several focal value propositions. Complementary activities by the different actors are required to realize the envisioned value propositions (Adner 2016). Apart from innovations in the form of novel products or processes, even novel business models can be pursued outputs of innovation ecosystems (Autio and Thomas 2018). In business model innovations, participation in the innovation ecosystem that introduces new ways to create, deliver and capture value creates a competitive advantage over actors outside the innovation ecosystem. Together, a diverse combination of stakeholders incorporates a wealth of ideas, views, and knowledge, which is particularly useful when exploring novel problems and seeking solutions while maintaining a wide solution space. As such, the output of innovation ecosystems is both unpredictable and beyond the capacity of a single actor yet shared among actors. In relation to value propositions, one can distinguish the explorative layer aiming for identifying opportunities for value creation, from the exploitative layer which aims to capture value from such novelities (Visscher et al. 2021). While the exploitative layer can be viewed on a project level, such as mega projects presented by e.g. Whyte et al. (2016), to find novel ideas and solutions the explorative layer requires relationships beyond the project scope – both regarding time and regarding actors and relationships. When aiming for value propositions in line with the emerging societal challenges, activities take place in the explorative layer.

The general relationship structure of innovation ecosystems can be characterized by different actors that provide complementary parts of innovations, products, or services, which are not necessarily bound by contractual arrangements. The strictness of the
requirements for participating in an innovation ecosystem varies from basic rules to strong control and formal agreements (Jacobides et al. 2018). In innovation ecosystems, there is a significant interdependence between actors’ inputs. Here, a relatively informal governance approach allows participants to take on dynamic roles in the venture towards delivering the value proposition (Valkokari 2015, Jacobides et al. 2018). This relatively informal and dynamic structure blurs the system boundaries, which can be particularly challenging in public contexts due to legislative barriers (Phillips and Ritala 2019).

Finally, innovation ecosystems are often orchestrated by a central actor that manages processes within the network and their effects on network innovation output by mobilizing knowledge, facilitating value appropriation and ensuring network continuity (Dhanaraj and Parkhe 2006). Although influential, this orchestrator does not necessarily control or manage the innovation ecosystem itself (Phillips and Ritala 2019). Instead, both the contractual conditions and the governance and control mechanisms in place may induce formality in innovation ecosystems. Depending on the preconditions, actors might change their involvement in terms of its intensity, period, and relationships. As a result, value propositions, actors, relations, institutions, legislation and the contextual environment co-evolve (Gomes et al. 2018).

In conclusion, innovation ecosystems can be understood as heterogeneous sets of interdependent actors in a network that exhibit low levels of formality and in which outcomes are produced that are beyond the capacity of individual actors. To explore the potential of the innovation ecosystem perspective for the infrastructure sector, we first introduce insights into the current dynamics in and barriers to project-transcending innovation in the infrastructure sector.

**Barriers to innovation in the project-based infrastructure sector**

Current societal challenges, such as the energy transition and a circular economy, require different parties to collaboratively develop innovative solutions that could also move beyond projects (Ferraro et al. 2015, George et al. 2016). In infrastructure, however, value is typically created in publicly commissioned individual projects being temporal organizations with multiple stakeholders (Olander and Landin 2008). In this context, the fragmented nature of the infrastructure sector hinders the creation of societal value (Håkansson and Ingemansson 2013, Bygballe and Ingemansson 2014), as knowledge and capabilities are increasingly dispersed between organizations (Ahuja 2007, Rutten et al. 2009). We refer to collaborations and outputs that are a consequence of thinking beyond projects as “project-transcending”. Barriers for project-transcending innovation in infrastructure mainly originate from the project-based structure of the sector on the one hand, and the publicness of the domain on the other hand.

**Barriers originating from the project-based structure**

Like any project, infrastructure projects are characterized by fixed goals and task specifications, with predefined timescales and budgets. These projects often embody poorly aligned relationships between the actors, including public clients, contractors, engineering firms and suppliers involved (Flyvbjerg et al. 2009). At the same time, however, project participants are simultaneously embedded in multiple organizations and interorganizational networks that are aligned for organizing various projects (Manning 2008). As a result, infrastructure projects are inherently relational and embody interactions that contrast with their contextual conditions (Fuentes et al. 2019). This competitive and inflexible nature of the sector’s structure impedes the achievement of the changes and innovations necessary to address societal challenges such as climate change and urbanization (Dulaimi et al. 2002, Rutten et al. 2009).

Another complicating factor is that projects have separate phases in which different organizations collaborate and that projects are treated as unique, temporary phenomena (Sheffer 2011). Moreover, varying organizational structures of supply chain actors hamper the introduction of novelties in the work practices (Harty 2005). Specifically, innovations do not only comprise novel combinations of materials but also unique combinations of processes and organizations, such that successful innovations, particularly in the context of diffusion, need to go beyond project boundaries (Rutten et al. 2009). Consequently, during the development of innovations, organizations could benefit from developing collaborative pathways that connect individual projects and go beyond collaborations that are bounded by project temporalities (Manning and Sydow 2011).

**Barriers originating from operating in a public domain**

Many other persistent challenges to interorganizational innovation in infrastructure projects stem from
the fact that most physical infrastructure has public asset owners and needs to be procured according to regulations that impact the public-private relationships (Siemiatycki 2011, Kuitert et al. 2019). These rules and regulations are primarily aimed at transparency and openness, creating a level playing field when spending taxpayers’ money. Single-project tendering processes prevent long-term collaboration and often go hand in hand with strict dyadic contractual arrangements in which the informal social ties are structurally neglected (Hällström et al. 2021). While in other construction domains, like housing, clients are often private entities allowed to initiate and continue relationships with their suppliers based on a strategic portfolio focus, procurement practices in infrastructure largely shape market conditions that impede cross-project diffusion of knowledge and innovation (Lundberg et al. 2019). This moreover hinders innovation in technical resources (Bygballe and Ingemansson 2014, Larsson et al. 2014), for example, in case of achieving a circular economy by means of standardization and prefabrication (Anastasiades et al. 2021).

**Enabling project-transcending innovation in construction**

Complex networks of stakeholders and long-term endeavours are required to overcome structural barriers to continuous, interorganizational innovation from a project-transcending perspective (Martinsuo and Hoverfält 2018). These type of innovations can be approached from different perspectives on collaboration in a construction context. For example, Hedborg and Karrbom Gustavsson (2020) take a project ecology perspective, which enables them to study interdependencies and interactions of actors performing projects close to each other within an urban district. Here, a positive effect on developing innovation processes was found for performing and managing projects both in parallel and sequentially. Other scholars, like Manning (2010) and DeFillippi and Sydow (2016), take a project network perspective to study innovation by interorganizational relations between project participants from previous collaborative projects and practices that extend the single project.

So far, the innovation ecosystem perspective has remained rather unexplored to enhance multiparty innovation in project-based industries. Known applications of the ecosystem perspective in a construction context mainly consider a single mega-project as an ecosystem (e.g. Davies et al. 2014, Pelton et al. 2017), or demonstrate the applicability of the concept centred around a collective of actors in a multi-project setting (Pulkka et al. 2016). In most of these studies, the project itself still plays a leading role.

Inspired by innovation ecosystem concept, we argue that conditions for innovation could improve by focussing on relations around a central value proposition that is broader than a project or a central actor. Hence, this paper introduces the innovation ecosystem as a perspective for understanding interorganizational collaboration and innovation on the wider emergent societal challenges that we are facing beyond the project scope. To provide a framework for analysing infrastructure cases, we will explain the application of the key features of this perspective to the infrastructure context in the next section.

**Conceptual framework**

In line with Thomas and Autio (2020) we position the value proposition in this research as focal point to explore the potential of the innovation ecosystem for addressing project-transcending societal challenges. Based on the exploration of innovation ecosystems literature in the previous sections, we distinguish four characteristics of innovation ecosystems as identified by Thomas and Autio (2020), and adapt these to match the structural elements relevant to collaboration and innovation in the infrastructure sector. This leads to the following main characteristics of potential innovation ecosystems in infrastructure: (1) involvement of heterogeneous actors; (2) strategic alignment of actors; (3) alignment with respect to a value proposition; and (4) governance structure. By considering the structural elements of the infrastructure sector as discussed in the previous sections, these characteristics are detailed in several indicators as explained below, which together constitute the conceptual framework for qualitatively analysing five infrastructure initiatives.

**Involvement of heterogeneous actors**

Innovation ecosystems involve *cross-sectoral networks* rather than being limited to sectoral boundaries, a characteristic that is positively correlated with innovative solutions (Alves et al. 2007). This is largely because unfamiliar actors might bring expertise that cannot be found within the sector. In the infrastructure context, this could, for example, mean that chemical companies are involved in construction material innovations or IT companies in digital twin
innovations. It is not only this heterogeneity that is typical of innovation ecosystems, but there is also a reliance on non-generic complementarities (Jacobides et al. 2018). Actors provide such non-generic complementarities with respect to the value proposition by offering unique skills or products that provide specific pieces of the puzzle needed to deliver the overall value proposition.

Collaboration in innovation ecosystems transcends the collection of conventional project participants, such as contractors, government agencies and engineering firms, and may include actors such as material suppliers, technological innovators or knowledge institutes, and civil society that cover the full quadruple helix (Carayannis et al. 2018). In addition to the industry, knowledge institutions and governmental bodies that are present in the triple helix model, a quadruple helix adds a fourth helix associated with “media and culture-based public”, allowing public society to become an integral part of innovation ecosystems (Carayannis and Campbell 2009, p. 206). Since the adoption of the innovation ecosystem perspective in an infrastructure context demands a wider view on the actors involved, we identify cross-sectoral networks, non-generic complementarities, and the quadruple helix as our three key indicators in analysing the actor heterogeneity of infrastructure initiatives.

**Strategic alignment of actors**

Combining the knowledge and expertise of various parties cannot only deliver a particular part of the solution, interorganizational collaboration can also result in solutions beyond the capacity of individual organizations (Ritala and Hurmelinna-Laukkanen 2009). In the infrastructure sector, alignment can be found in the co-opetition between individual market parties, collaboration between contractor and client, and in the involvement of actors throughout the entire infrastructure process rather than only in specific parts of the asset lifecycle.

Given that innovation ecosystems are dynamic networks rather than fixed structures, actors might only be involved for a limited period and with changing intensities and roles. This requires a perspective that goes beyond the traditional project structures and invites reconsideration of the traditionally adversarial client–contractor relationships (Ruijter et al. 2021). Consequently, actors might be dynamically involved throughout the construction processes in order to fully utilize their input and expertise, such as the involvement of demolition contractors in a pre-project stage to optimize products and processes over the asset’s entire lifespan (Van den Berg 2019).

So, whereas suppliers in regular construction processes often become involved through a contractor, an innovation ecosystem perspective would allow involving such knowledgeable parties directly and in earlier stages of the process. This requires distinct actors to align their work processes and collaborate towards a central value proposition to collectively generate a desired outcome, a phenomenon known as co-specialization (Ritala et al. 2013). This strategic alignment has the potential to both find integral solutions and stimulate lifecycle thinking. We therefore identified co-opetition, the dynamic involvement of actors and co-specialization as three indicators to be used in analysing the strategic alignment of actors involved in project-transcending infrastructure initiatives.

**Alignment with respect to a value proposition**

Aligning incentives is key to facilitating the coordination of the various actors’ inputs required to go beyond project-specific solutions. In innovation ecosystems, this is achieved by creating conditions for developing a shared value proposition that is beneficial to all parties involved. Such value propositions could contain operational or economic goals of, for example, cutting budgets, but could also relate to addressing wider public challenges, such as climate change or digitalization. While the infrastructure sector is known for distrust and poor communication (Van Oorschot et al. 2020), the innovation ecosystem perspective offers a system that fosters trust by means of goal alignment. The alignment of incentives therefore provides favourable conditions for collaboration and transparency (Fischer and Pascucci 2017).

The alignment of incentives enables sets of actors to pursue goals that go beyond the success of a single project. Value propositions could therefore go beyond project performance in terms of time, budget and quality to outcomes related to overarching goals and missions, such as carbon reduction and social inclusion. This can be aligned at an industry level but might also be positioned at the level of an infrastructure client organization or a public-private consortium. Notwithstanding, it is important that its initiation originates beyond the scope of a single project to align multiple actors beyond the temporalities of projects. This can contribute to solutions that projects or project portfolios can exploit throughout the wider sector and encourages parties to invest in innovation, since the potential benefits extend over a longer term
Successful innovation ecosystems provide a viable business case for all actors involved. This will require radical changes in how construction activities are organized in terms of reward systems, risk allocation, contracting methods and, above all, the level of trust between parties. Based on these arguments, we will specifically look at the shared value proposition, the alignment of incentives and the viability of the business case for all actors to assess alignment with respect to the value proposition of infrastructure initiatives.

**Governance structure**

Innovation ecosystems are primarily non-contractual in nature, with autonomously acting participants, characterized by interdependence through co-specialization. The shared value proposition ensures that all participants can find their position within the innovation ecosystem with low levels of formality and a strong reliance on relational governance (Colombelli et al. 2019). This enables participants to take flexible roles throughout the process through governance in a co-alignment structure that goes beyond formal contracts (Thomas and Autio 2020). Accordingly, the governance mode may vary from top-down and hierarchical to informal coordination. Infrastructure projects are usually highly formalized and procurement legislation generally impedes the formation of long-term collaborations and project clusters. The innovation ecosystem perspective, however, demands ways to increase autonomy and flexibility within projects and entails forms of self-organization. This stimulates the exploitation of expertise (Poirier et al. 2016). It therefore provides the conditions for actor heterogeneity, which requires fundamental changes to how infrastructure projects are currently governed. Also, the self-organizing potential is affected by whether or not and the way in which a central actor orchestrates both processes and actors within the network (Phillips and Ritala 2019). Given its large stake in addressing long-term and societal challenges, the orchestrator in the infrastructure sector often is a public actor that, although bounded by procurement regulation, constructs stakeholder networks with the aim of adding value for society (Eriksson et al. 2019, Fuentes et al. 2019). Contrarily, such orchestrator could also come from the private sector, where a private organization actively connects and aligns actions of different parties with the aim to develop a particular innovation. However, the road towards broad implementation of this innovation is more uncertain within current sectoral structures due to the limited possibilities of public organizations to apply unsolicited proposals (Coenen et al. 2022). Hence, in this study, the governance structure will be assessed based on the indicators of low levels of formality, co-alignment structure and self-organising potential.

**Research approach**

Given that the innovation ecosystem perspective has proven to be valuable in various fields in stimulating change and innovation with respect to wider societal challenges (Jütting 2020), we will explore its applicability in a particular segment of the Dutch construction industry that focuses on the development and maintenance of physical infrastructure such as bridges, roads and waterways. We analysed five existing exemplary public infrastructure cases by applying the conceptual framework on innovation ecosystem characteristics – actor heterogeneity, strategic alignment of actors, alignment with respect to a value proposition and governance structure – and associated indicators as described in the previous section.

**Case selection and description**

For selecting cases we used a purposive sampling strategy (Campbell et al. 2020). The selection was based on the identification of noteworthy infrastructure initiatives in terms of project-transcending collaboration and value creation related to societal challenges such as circularity and sustainability. In all cases, either a client, public-private network or contractor initiated a value proposition in line with long-term challenges that could not be resolved within one or several single projects. To this end, we consulted experts in the Netherlands (e.g. fellow researchers in the infrastructure sector and managers with a broad network) and compiled a list of ten potential cases that facilitate a broader exploration of the innovation ecosystem potential. Next, we collected more information on these cases through publicly available documents to identify whether two or more of our four innovation ecosystem characteristics (actor heterogeneity, strategic alignment of actors, alignment with respect to a value proposition and governance structures) were at least to some extent present. We used information we found online, such as news articles, web pages, YouTube videos, as well as documentation sent to us by the experts we consulted, such as tender documentation. Next to the presence of innovation ecosystem characteristics, the ten potential cases were
evaluated on three aspects: (1) organizations linked to the initiative are involved on a long term basis; (2) the goal of the initiative includes a central value proposition that is impossible to accomplish within a single project; and (3) the central value proposition is related to societal challenges. We particularly looked for typical or striking elements that made the initiative unusual for the Dutch infrastructure sector, such as the number of parties from outside the construction industry and the underlying business models or contracts. This approach enabled us to either confirm or refute inferences drawn from individual cases (Eisenhardt and Graebner 2007), and resulted in a set of five cases.

The five selected cases are as follows: an innovative long-term and trust-based collaboration using long term framework agreements with three contractors to ensure wastewater treatment from the Dutch Waterboard of Limburg (Case 1 Water Treatment); the CHAPLIN consortium which aimed to explore and introduce lignin as a substitute for bitumen in asphalt, where, among others, infrastructure and paper industry parties closely collaborated (Case 2 Bio-pavement); the “Circulaire Weg” programme that introduced a service-based business model to be tested in several road-contracting pilot projects to contribute to the circular economy (Case 3 Circular Road); the “Cirkelstad” knowledge platform which aimed to connect and align all willing actors in the built environment to provide conditions for the implementation of circular and inclusive cities (Case 4 Circular City); and the “Asfalt Impuls” programme, involving a multitude of different organizations who aim to further knowledge on sustainable asphalt in order to achieve the sector’s sustainability goals (Case 5 Asphalt Innovation). Table 1 gives an overview of the domains of interest, initiators, collaborative structures, parties involved and time horizons for each case.

**Data collection and analysis**

After the initial analysis to select suitable cases, additional data on the five cases was collected using documents from professional magazines, newspapers, websites, and other journals. This resulted in a data set containing 52 data sources consisting of written documents and videos. As a first step in analysing the cases, we structured the data per case and used the case datasets to summarize the different cases in terms of the governance structure, the constellation of participants in the initiative, the aim of the initiative and the way in which participants collaborated. The

<table>
<thead>
<tr>
<th>Case</th>
<th>Domain of interest</th>
<th>Initiator</th>
<th>Collaborative structure</th>
<th>Parties involved</th>
<th>Time-frame</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Water Treatment</td>
<td>Construction and maintenance of wastewater treatment plants</td>
<td>Waterboard of Limburg (WBL) (public client in infrastructure)</td>
<td>Formal framework agreement including three contractors</td>
<td>Client, three contractors, suppliers, independent process coach and others</td>
<td>Flexible with maximum of six years</td>
</tr>
<tr>
<td>2 Bio-pavement</td>
<td>Development and commercialization of lignin-based asphalt</td>
<td>Circular Biobased Delta Foundation (shared initiative of public and private parties)</td>
<td>Informally arranged collaboration followed by formalization of the project</td>
<td>Twenty-eight organizations, including public bodies, knowledge institutes and cross-sectoral market parties</td>
<td>Indeterminate</td>
</tr>
<tr>
<td>3 Circular Road</td>
<td>Exploring the infra-as-a-service business model in pavements</td>
<td>Dura Vermeer (contractor) Foundation Cirkelstad (shared initiative of public and private parties)</td>
<td>Informally arranged collaboration followed by formalization of the project</td>
<td>One contractor, one knowledge institute, one consultancy firm, independent programme manager, two banks and six public clients</td>
<td>Two years (with long-term as-a-service contracts)</td>
</tr>
<tr>
<td>4 Circular City</td>
<td>Connecting actors that aim for circularity in the built environment</td>
<td>Foundation Cirkelstad (shared initiative of public and private parties)</td>
<td>Formal covenant with participants, working groups and regional ad hoc organisations</td>
<td>Multiple organizations from across different sectors, including knowledge institutes, program managers, and market parties</td>
<td>Indeterminate</td>
</tr>
<tr>
<td>5 Asphalt Innovation</td>
<td>Knowledge building on asphalt in line with societal challenges</td>
<td>Rijkswaterstaat (public client in infrastructure)</td>
<td>Formal covenant with participants, working groups, and regional ad hoc organisations</td>
<td>Multiple organizations from across different sectors, including knowledge institutes, program managers, and market parties</td>
<td>Indeterminate</td>
</tr>
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different data types provided different ‘parts of the puzzle’ in developing the case descriptions, going iteratively back and forth through the obtained information (Eisenhardt 1989). There was an average number of about ten data sources per case, which made the dataset per case comprehensible and manageable. Therefore, the analysis of the data for each distinct case was conducted manually. This first step resulted in five general case descriptions and helped the researchers in gaining a deeper understanding of the different cases.

As a second step, the four innovation ecosystem characteristics were used to enhance the five case descriptions with specific information regarding innovation ecosystem indicators for each characteristic. Again, the researchers followed an iterative approach to make sense of the data. Through cross-case comparison (Eisenhardt 1989), different elements were identified in relation to the characteristics’ underlying indicators, such as the level of formality and cooperation. The innovation ecosystem characteristics and indicators were used in a qualitative manner to distinguish between the different cases. For example, the heterogeneity characteristic was further specified by distinguishing between distinct types of sectors, types of actors and types of inputs. When in this example actors from sectors other than infrastructure were involved in the initiative, this was understood as a form of heterogeneity. As a second example, when the initiative depended strongly on actors that offered specific and unique types of products, knowledge, or services with respect to delivering the overall value proposition, we described how the initiative includes non-generic complementarities. In cases where the information collected was inadequate, we searched for additional documentation specifically on the aspects that remained unclear, and reached out to involved actors of the initiatives to verify our data, leading to complementary informal interviews with several of the project managers and board members of the cases.

Based on the validated descriptions of the cases and descriptions of the indicators per case, it became clear how each case dealt with collaboration and innovation in a project-transcending setting. Based on these elaborate accounts of the cases, a comparison between the five cases was conducted. Remarkable elements and achievements of the cases were put side-by-side and were related to the elements as described in the conceptual framework. This enabled us to reveal the potential opportunities, benefits, and challenges in applying the innovation ecosystem perspective on an industry-wide level. The outcomes of this analysis are presented in the next section.

**Results**

Table 2 provides an overview of the four main innovation ecosystem characteristics and their indicators on the vertical axis, and a summary of the related elements found in the five cases on the horizontal axis. Matches between cases and indicators are indicated in **bold**. These matches are determined based on a qualitative assessment of the cases based on the data sources, which are individually described in the next sections. For instance, regarding cross-sectoral networks, in Case 1 we only could find actors that are generally affiliated with the wastewater industry, while, in Case 2, parties were found from the asphalt sector and the paper industry. The latter was hence indicated in bold. Table 2 shows that some indicators were found in all cases, while others were only present in one or two cases. The results are discussed in greater depth in the next sections according to the four innovation ecosystem characteristics.

**Actor heterogeneity**

In all five cases, various actors from the supply chain were involved, but in only one case did actors from outside the infrastructure sector play a role. This was in Case 2 Bio-pavement, which actively sought to combine knowledge on asphalt paving with the chemical and paper production industries, where lignin is a residual product released during the production of, among other things, pulp and cellulose. This case demonstrated that by actively reaching out beyond sectoral boundaries, solutions were found that open a solution pathway that could potentially transform the asphalt subsector. Deliberate collaboration across the value chain was organized by the orchestrating foundation to create a network of actors in bio-pavement rather than a linear supply chain. The network of the bio-pavement case consisted of ten market organizations, nine public organizations and five research institutes. Furthermore, the network crossed several regions, sectors and domains aiming to achieve a system of industrial symbiosis. Although the other four cases did not go beyond the sector’s boundaries in terms of the actors involved, their organization of the supply chain and adoption of a network perspective resulted in long-term actor involvement throughout all construction phases. This enabled a more effective exploitation of all the actors’ knowledge and skills.
Table 2. Summary of the innovation ecosystem characteristics and indicators with respect to the five cases studied. Strongly matching traits are indicated in **bold**.

<table>
<thead>
<tr>
<th>Case 1 Water treatment</th>
<th>Case 2 Bio-pavement</th>
<th>Case 3 Circular Road</th>
<th>Case 4 Circular city</th>
<th>Case 5 Asphalt innovation</th>
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</thead>
<tbody>
<tr>
<td><strong>Actor heterogeneity</strong></td>
<td>Cross-sectoral networks</td>
<td>Infrastructure actors only</td>
<td>Actors from other industries involved</td>
<td>Infrastructure actors only, but acting in non-conventional roles</td>
</tr>
<tr>
<td></td>
<td>Non-generic complementarities</td>
<td>Specific module suppliers</td>
<td>Specific actors with non-generic complementarities</td>
<td>Representation of triple helix, no active involvement of society</td>
</tr>
<tr>
<td></td>
<td>Quadruple helix</td>
<td>Representation of triple helix, no active involvement of society</td>
<td>Representation of triple helix, no active involvement of society</td>
<td>No coopetition</td>
</tr>
<tr>
<td><strong>Strategic alignment of actors</strong></td>
<td>Coopetition</td>
<td>Coopetition between contractors</td>
<td>Coopetition between contractors and suppliers</td>
<td>Dynamic involvement of public clients (in pilot projects)</td>
</tr>
<tr>
<td></td>
<td>Dynamic involvement of actors</td>
<td>Continuous and dynamic involvement of relevant parties</td>
<td>Continuous and dynamic involvement of relevant parties</td>
<td>Dynamic involvement of public clients (in pilot projects)</td>
</tr>
<tr>
<td></td>
<td>Co-specialization</td>
<td>Parallel and partly co-specialized development cycles for modular parts</td>
<td>Utilizing all participants’ specialisms in integrated development cycles</td>
<td>Utilizing all participants’ specialisms in integrated development cycles</td>
</tr>
<tr>
<td><strong>Alignment with respect to a value proposition</strong></td>
<td>Shared value proposition</td>
<td>“Good” wastewater treatment plants and a smooth work process</td>
<td>Bio-based asphalt innovation</td>
<td>New business model in infrastructure (as-a-service)</td>
</tr>
<tr>
<td></td>
<td>Alignment of incentives</td>
<td>Alignment by fair and long-term sharing of risks and benefits</td>
<td>Alignment by perspective on pilots and future work</td>
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<td>Low levels of formality</td>
<td>Formal framework contracts, but low formality within the framework</td>
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<tr>
<td></td>
<td>Co-alignment structure</td>
<td>Flexible governance structure to fit programme goals</td>
<td>Informal governance structure allowing for external actors to participate</td>
<td>Inflexible governance structure</td>
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<tr>
<td></td>
<td>Self-organizing potential</td>
<td>Initiated and managed by Waterboard</td>
<td>Self-organizing but orchestrated by a central foundation</td>
<td>Initiated by contractor, yet collaboratively steered</td>
</tr>
<tr>
<td></td>
<td><strong>Governance structure</strong></td>
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<td></td>
<td>Co-alignment structure</td>
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<tr>
<td></td>
<td>Self-organizing potential</td>
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</tbody>
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Not involving actors from outside the infrastructure sector and providing the conditions necessary to go beyond the sectoral boundaries contrasts with typical innovation ecosystems that involve actors that offer non-generic complementarities with respect to the value proposition. Nevertheless, in Case 1 Water Treatment, non-generic module suppliers were added to assemble their innovative modular wastewater treatment plant. This arrangement used framework agreements to purchase specific solutions from specific suppliers and avoid project-oriented procurement restrictions. This enabled the client to compile a catalogue with solutions aimed at standardizing specific wastewater treatment plant technologies and achieving a standardized and integrally sustainable system design.

In all five cases, actors outside the conventional supply chain, such as knowledge institutes, were involved next to the usual actors as governments and marked organizations, resulting in a representation of the triple helix. The main reason to involve knowledge institutes seemed to be the frontrunner role of the initiatives, which encouraged reflexive activities related to experimenting, learning, and reflecting. The fourth helix of civil society was not involved in any of the initiatives. Since the customer is in most infrastructure assets not an individual consumer, but a governmental client that represents societal interests, the absence of the fourth helix does not seem to be problematic for the ecosystem development in these particular cases. However, the deliberate inclusion of this fourth helix might still be valuable in cases where the value proposition directly affects citizens, such as urban infrastructure works.

To summarize, we found that the actor heterogeneity was in most of the cases rather similar to those in conventional project settings, with only Case 2 Biopavement clearly showcasing the potential benefits of crossing sectoral boundaries. The need for extensive actor heterogeneity seems strongly connected to a value proposition that goes beyond what conventional infrastructure actors can achieve.

**Strategic alignment of actors**

The deliberate alignment of actors in terms of mutual dependencies and project-transcending collaboration was found in all five cases, although not all to the same extent. Particularly in the product-oriented cases (Cases 1 and 2), actors were aligned in line with innovation ecosystem principles in such a way that cooperation between parties played a key role. Nevertheless, contractors still had to compete in tenders for projects outside the scope of the studied networks, such as infrastructure projects commissioned by other public clients. The results from Case 1 Water Treatment indicate that involving several contractors in one multi-year framework agreement stimulated cooperation between the contractors involved. In this case the three contractors were primarily selected for their collaboration competences rather than for traditional criteria such as lowest price or price/quality ratio. As part of the contract, the risks and profits involved were shared fairly among the client and the contractors. The resulting collaborative attitude of all parties resulted in a considerable reduction of cost and time overruns, as well as an increased number of unconventional solutions. It also promoted cross-project learning, standardization, alignment of incentives between all actors, and enabled investments for innovation. An external process coach was involved to discourage any tendencies by parties to adopt traditional opportunistic behaviour rather than collaborative attitudes. Her job was to independently safeguard the collaborative relationships and to resolve potential tensions through constructive dialogue.

Case 4 Circular City and Case 5 Asphalt Innovation were primarily knowledge-oriented and showcased limited collaboration, which resulted in limited or no competition: knowledge was shared among participating organizations, but participants did not collaboratively exploit this knowledge to provide novel solutions. Within these networks there was no direct relation to immediate profits or work, which likely explains the absence of competition between the participants. Hence, in the knowledge-oriented cases overall cooperation was limited. These cases did not pose any procurement challenges, leading to relatively open system collaboration structures and the involvement of various actors and actor types. In Case 4, the actors were primarily aligned on a regional level, in which individuals orchestrated this alignment. Wider outcomes in terms of knowledge or lessons were directed towards the national level and shared within the wider initiative. As such, there was little interdependence and the actor heterogeneity largely depended on mere coincidence. In Case 5, all the members were able to contribute to the programme and could propose projects in line with the initiative’s value proposition. A central steering group decided which of the proposed projects would be initiated as thematic working groups. As such, there was little room for deliberate upfront actor alignment.
In Case 1 Water Treatment and Case 2 Bio-pavement the actors were strategically aligned to create a clear flow from development, through testing, to implementation. Especially the Bio-pavement case showed a remarkably high actor interdependence with respect to the goal. This resulted, on the one hand, in a high level of collaboration between the contractors and, on the other, in forms of co-specialization. As such, sustainable innovations were successfully introduced in pilot environments that would have been difficult to introduce in single-project and single-industry environments. Key to these cases was the project-transcending collaboration between clients and market parties and between the market parties themselves. This was mainly achieved through reconsidering the traditional actor alignment structures and adopting a long-term output orientation rather than a project focus.

Overall, the current infrastructure sector does not seem to provide the tools needed to strategically align actors in line with innovation ecosystem principles. In the two product-oriented cases (Case 1 and Case 2) this was solved by non-conventional and project-transcending forms of collaboration. These project-transcending collaborations seem to be essential to facilitate the cocompetition and co-specialization necessary to address long-term objectives.

**Alignment with respect to the value proposition**

We only selected cases aiming at value propositions that addressed goals beyond single projects. We found that rather than being an objective of a client organization only, these value propositions were shared and supported by all the actors involved through the alignment of incentives. In Case 1 Water Treatment, however, the value proposition was not that different from conventional construction projects. Nevertheless, in combination with the contextual conditions that were set by the client – in particular incorporating principles for hassle-free collaboration and a fair distribution of project risks, gains, and losses – the actors involved committed to collaboration in order to accomplish the project and programme goals. The value propositions were, however, not accurately stipulated and appeared to range from standardization to increasing sustainability. This created flexibility throughout the contracted period and the dynamic incorporation of long-term value-based objectives.

We found that all the cases employed numerous ways to align the incentives with the value propositions. Four of the five cases had sustainability-oriented value propositions that were aligned with the contributions of the actors. In Case 4 Circular City, for instance, actors were connected through a platform in which collecting, sharing, and diffusing knowledge was aimed at improving sector-wide knowledge on circularity and inclusivity in the built environment. The value proposition of Case 3 Circular Road involved as-a-service road contracts that aligned the actors around specific long-term contracts that emphasized circular principles in the integration of construction, maintenance, and demolition. Novel forms of contracting, relation-building and collaboration were found to be essential for aligning the incentives of the actors and activities to a central value proposition and the case data showed several effective examples of such alignment strategies. In addition, in all cases the actors participated on their own accord and hence signed up for aligning towards the central value proposition beforehand.

Overall, in all the cases participating in the network or initiative seemed a promising move when considering the viability of the business case for each participant. Although the participants could not always expect to profit directly, the advantages of participating in a broader network initiative, such as expanding business relations, access to knowledge and possibilities to innovate with less risk, delivered potential future value for other projects.

**Governance structure**

The low level of formality that typically characterizes innovation ecosystems could only be identified in two cases: in Case 2 Bio-pavement a consortium was established and in Case 4 Circular City the governance was purely relational around a central platform. However, product-oriented Case 1 Water Treatment and Case 3 Circular Road demonstrated several other ways to increase collaboration with low levels of formality within the more formal boundaries of public procurement. Case 1 achieved a low level of formality by procuring collaboration for several years instead of project delivery within a strict performance frame, while Case 3 shifted from purchasing a product towards purchasing a multi-year service delivery. This resulted in cross-project collaboration and tighter client-contractor relationships in which relational governance mechanisms overshadowed the initial, contractual governance as the collaboration proceeded. The relational governance mechanisms offered more possibilities to make better use of the participants’ strengths throughout the process. Overall,
apart from Case 4, the final outputs were nevertheless eventually formally stated in contracts.

In four out of five cases, the regular procurement practices were either omitted or adjusted to establish relationships with less formality and to stimulate the collaboration needed to achieve cross-project challenges. As such, an overall shift was made from contractual governance mechanisms towards relational governance mechanisms. This allowed for a better alignment between actors with respect to the envisioned value proposition based on their skills and knowledge to contribute to it.

All the cases extended the scope beyond single projects, emphasizing the need for durable relationships and resulting in higher degrees of mutual trust compared to typical stand-alone infrastructure projects. For example, although the encompassing framework agreement in Case 1 was formally procured, we found that the collaboration within the framework agreement was largely horizontal and informal.

In Case 2 and Case 4, the networks were self-organizing and/or informally governed, based on rather informal networks. In Case 2, the network was always open to new members, and the only condition for participating in the network was that members must add something to the collaboration and value proposition. This non-formal structure led to a diverse range of parties becoming involved, all with specific strengths and complementarities that contributed to the central goal: bio-based asphalt development.

To summarize, in most cases the nature of the work and legal boundaries did not seem to allow for a high degree of non-formal governance. Nevertheless, in all the cases actors did find ways to shift the governance from contractual towards relational. The lower levels of formality contributed significantly to a more open and dynamic attitude towards solutions that went beyond the project scope.

**Benefits of taking an innovation ecosystem perspective**

Each case indicated different benefits and challenges by taking the innovation ecosystem perspective on innovative value propositions and project-transcending collaboration. These are discussed below for each case.

In Case 1 the procurement of multi-year framework agreements with multiple contractors provided the conditions required for aligning objectives towards a shared project-transcending goal that include a novel modular wastewater treatment plant in line with the water board's wider circular economy ambitions. This was primarily achieved by sharing risks and benefits fairly, and by managing the underlying projects through collaboration on a cross-project perspective for four years. In addition to the benefits for innovation, these agreements also led to conditions that allowed for project-transcending standardization efforts. Reflected by the presence of non-generic complementarities, strong coopetition and deliberately aligned incentives, the conditions were created for addressing challenges beyond a project's scope and deliberately innovating to meet these challenges.

Rather than employing novel ways of collaboration to provide conditions for innovation and change, Case 2 was initiated around a clear innovation purpose: to address the transition towards carbon-neutral infrastructure through bio-based alternatives. The way of organizing – cross-sectoral networks, a high degree of coopetition, dynamic partner involvement, and specified participant roles – was a consequence of this objective rather than an act to trigger innovation. Nevertheless, the close similarities with the innovation ecosystem characteristics led to an effective innovation pathway that covered all the phases from idea development, through experimentation, to implementation beyond single project settings. This approach turned out to be highly effective for exploring and implementing bio-based substitutes for bitumen in asphalt and later on linked to a larger cross-sectoral programme aimed at addressing overarching objectives concerning sustainability and the circular economy.

In a similar vein, Case 3 was initiated around a particular business model innovation to respond to a wider societal challenge: the circular economy. Contributing to this societal challenge was the main reason for public clients to join the market-driven initiative. Despite having only limited similarities with the innovation ecosystem characteristics, the extension of the project scope beyond the conventional design and construction phases enabled the actors to align the incentives towards making infrastructure decisions that were more resource efficient. The value proposition was centred around the promising presumption that having integrated lifecycle stages as the responsibility of contracting actors would lead to more resource-efficient behaviour, and hence wider economic and environmental benefits in the long run.

In contrast to the above three cases, Case 4 did not focus on cross-project activities but on transforming the wider built environment. As such, this network-level approach did not directly contribute to specific
innovations, but mainly to knowledge diffusion and collaboration to accelerate a market transformation towards circular practices. In particular, the relational governance structure enabled participants to take on dynamic roles in the network towards meeting the value proposition in context- and case-specific settings.

Although Case 5 had more concrete objectives than Case 4, it was also aimed at wider sectoral improvements. The long-term policy objectives were strongly interrelated with innovation and with change objectives such as closer collaboration among client organizations, market parties and research institutes. By utilizing thematic working groups, directions towards concrete solutions were explored and developed in a highly heterogeneous and cross-project setting. The case platform represented almost the entire Dutch asphalt supply chain and created opportunities for wider standardization in line with policy objectives. This largely government-led initiative thus contributed directly to the societal challenge-oriented strategic missions of the Dutch government.

Despite the different objectives and organizational structures, in all the cases the potential for change was increased by stepping out of the conventional project setting. A consistent governance system in which their value proposition was shared among a broader set of actors or time horizons seemed to have created the opportunities for pursuing innovation in line with project-transcending societal challenges. As such, the results indicate that working in line with innovation ecosystem principles seems both feasible and beneficial with respect to achieving value propositions beyond the project scope.

Nevertheless, it is important to note that all cases fundamentally differ in structure and context. There is probably no ideal innovation ecosystem model, formula or archetype for achieving project-transcending innovation. Based on this exploration we can carefully speculate if stronger implementation of innovation ecosystem principles could have increased the effectiveness of achieving the value propositions as set by the actors in these specific cases. In Case 2, for example, other industries contributed to innovative solutions with different technologies and knowledge. Extending the heterogeneity of the partners might hence have widened the solution space and consequently the value creation in this case. Similarly, more room for self-organization and emergence is likely to have contributed to the origin of non-conventional solutions and eventually a wider sector support to achieve the value proposition regarding asphalt innovation in Case 5.

Reflection and discussion

While scholars such as Davies et al. (2014) and Whyte et al. (2016) introduced the ecosystem perspective in a project environment, we explored its potential for facilitating value propositions from a project-transcending angle. In line with Ferraro et al. (2015), our analysis of the five cases from the Dutch infrastructure context confirms that the presence of innovation ecosystem principles allows for actor relationships to develop and provides conditions to foster long-term engagement towards a shared goal. Moreover, this perspective provides a continuous and value-based economic view beyond conventional single object-oriented project settings and occasional coalitions (Halman 2018). As such, the innovation ecosystem perspective allows the value proposition to exceed the project scope, which is considered crucial for addressing societal challenges (Ingold et al. 2019).

In line with Pulkka et al. (2016), we identified a potential benefit of adopting an innovation ecosystem perspective in relation to innovation and change in the construction industry. Whereas Pulkka et al. (2016) placed a network view centrally to increase value creation in a network context, we positioned project-transcending value propositions as focal point. This is an essential step for the construction industry to address societal challenges, because seeking to achieve societal missions, such as climate neutrality and circular economy, requires solutions that go beyond detached industries or single supply chains. Actors need to align incentives beyond conventional project settings and create long-term commitment to shared objectives (Jütting 2020). The innovation ecosystem perspective could hence play a significant role in achieving societal challenges on a sectoral level, for example, by providing specific insights on initiating or changing institutions that currently appear to hinder innovation and change.

Our analysis revealed that longer-term and less contractual cross-sectoral relationships can result in solutions that go (far) beyond the scope of conventional project-based public-private infrastructure supply chains in the infrastructure context. Many of the innovations and solutions in the studied cases essentially trace back to the informal relationships between actors. This is in line with previous work on collaboration in construction (e.g. Hällström et al. 2021). We found that innovative solutions with a significant impact regarding the project-transcending value propositions were largely the result of relational and long-standing actor interactions.
Previous work distinguishes between two layers in innovation ecosystems (Visscher et al. 2021): the explorative layer focused on developing knowledge and opportunities for innovation, and the exploitative aimed at executing work efficiently and effectively. The results of our study indicate that whereas the latter can be achieved within the existing project-based structures, the former requires fundamental changes to practices and the adoption of a project-transcending perspective. So, for the innovation ecosystem perspective to be effective in delivering long-term value propositions in public project-based sectors like infrastructure, one should step away from relying on the requirements within or between single projects. Since exploration precedes exploitation, a well-functioning explorative layer may lead to an exploitative layer of projects with different kinds of partners and value propositions (Visscher et al. 2021).

Our study revealed novel approaches to the explorative layer in the form of pilots or field-labs that fit the early phases of systemic transitions (Rotmans and Loorbach 2009). However, upscaling solutions from pilot environments to regular practice remains challenging. Balancing between collectives of actors that explore new solutions, those that exploit these solutions, and those that both explore and exploit, could be instrumental in addressing the challenges on a systemic level (Van den Buuse et al. 2021, Visscher et al. 2021).

Finally, one should be aware that an innovation ecosystem perspective requires fundamental changes in terms of interorganizational governance. Such systemic reconfigurations take time and perseverance and would, next to novel technologies and approaches, require a cultural and processual shift throughout the sector (Grin et al. 2010). The construction sector would have to change culture from relying on formal contractual arrangements based on established roles and routines to trust-based social ties in long-term collaborative relationships (Hedborg and Karrbom Gustavsson 2020, Hällström et al. 2021). Hopefully, our results offer a starting point for shaping this challenging journey.

Conclusion

Given the temporal complexities of project settings, it remains challenging to increase the collaborative action needed for providing the conditions for change and innovation in the construction industry. We aimed to contribute to this challenge by addressing the long-standing call by Bygballe and Ingemansson (2011, p.169) to establish ways to “see the benefits of interacting over time and attempt collaboration across projects” in the infrastructure domain. This was done by adopting the innovation ecosystem perspective and by structurally applying it to construction. We showed how it can offer a different understanding of change and innovation compared to the dominantly project-based structure and relatively homogeneous sector perspectives.

Collaboration in accordance with the principles of an innovation ecosystem can add value by shaping consortia of actors towards wider societally oriented value propositions that produce innovations beyond the benefits of single projects. This does not only include the alignment of actors with respect to the overall value proposition, but also the deliberate alignment of actors’ activities to achieve such aspirations. Our research shows that using framework agreements and programmatic collaborations are promising directions in enabling long-term and diverse collaborative initiatives that have the potential to grow into practices that fit the innovation ecosystems perspective. As such, the innovation ecosystem perspective provides a promising starting point for understanding and establishing the conditions required to deal with the major societal and sectoral challenges.

Utilizing this potential would require taking full advantage of the competences of a more heterogeneous set of individual actors, while also keeping eyes peeled for actors outside the conventional value chain and the sectoral boundaries. Since the existing institutional settings of our sector do not easily accommodate this, substantial changes will be required in conventional role structures and work practices. This collaborative transformation needs substantial effort in terms of experimentation, evaluation, and learning. Key factors are value-based contracting, partnering, procurement, risk, profit allocation, and facilitating trust-based relationships. Working in ecosystems will also substantially impact the economic systems and business models in which infrastructure actors operate. Inevitably, this transition processes will continue to increase the complexity of the construction industry as a system.

Limitations and further research

Given the potential benefits of a wider adoption of the innovation ecosystems perspective in construction, we strongly argue for further research into its potential applications and specific theory development for project-based environments. Although our study was
confined to the infrastructure context, we also expect the potential of an innovation ecosystem perspective to be beneficial to the wider construction sector. For example, commercial real estate and office developments are less restricted by public procurement law, which may increase the space for long-term collaboration and allow for higher degrees of relational governance than infrastructure. Building construction projects usually also have a diverse set of public and private stakeholders involved which could change the degree and types of complexity regarding alignment of incentives towards a shared value proposition. Finally, the fact that real estate assets are not part of a network, which is the case in infrastructure, could also affect the type of value propositions. This requires further research.

We put relatively little emphasis on how the various cases emerged or why they organized themselves as they did. In addition, the conceptual lens does not provide ingredients for developing or managing innovation ecosystems. Further research could deepen this exploration, for example by studying cases that embody several innovation ecosystem characteristics in greater depth, in a more quantitative way or over time, to create a longitudinal view of evolution of innovation ecosystems in line with Brunet et al. (2021). This would also enable studying the different development trajectories from a multilevel view on organizing as applied by Sydow and Braun (2018), providing further insights into the institutionalization of necessary conditions for innovation ecosystems to emerge.

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