

EXPLORING THE INNOVATION ECOSYSTEM CONCEPT FOR A CONSTRUCTION INDUSTRY IN TRANSITION

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The construction industry is increasingly facing societal challenges, such as climate change, resource scarcity, and digitalization. Traditional ways of organizing construction appear to be unsuitable for coping with these challenges. This calls for more systemic solutions in construction that reach beyond single projects or sectors to transform to a more resilient society. In this research, the innovation ecosystem perspective is explored to open up new horizons for dealing with the challenges. The innovation ecosystem can be understood as a multi-stakeholder network around certain innovative value propositions. Several theoretical innovation ecosystems characteristics are applied to the construction context by means of two illustrative cases from the Dutch construction sector. Results indicate that the innovation ecosystem perspective has the potential to both deal with the challenges involved and foster the innovativeness required for transitioning the sector. Benefits include the consideration of actors that are outside the construction domain, such as organizations for data management in the context of the circular economy, as well the long-term relation building among interdependent actors. However, additional case study research is needed to explore the full potential of its application in construction.

Keywords: ecosystem; collaboration; innovation; projects; societal challenges

INTRODUCTION

Construction projects become increasingly multi-disciplinary, complex and interdependent (Luo *et al.*, 2017). In addition, the industry is facing societal challenges such as climate change, Circular Economy, digitalization and changing mobility demand. These challenges require changes and innovations that exceed the knowledge, skills and capacity of single organizations (Shiu *et al.*, 2014). To contribute to these challenges in the increasingly complex construction context, new ways of producing, managing and innovating are needed throughout the sector (Wieser *et al.*, 2019). Therefore, both collaboration and thoughtful alignment of processes are required to take advantage of the complementary attributes of actors involved in construction works (Melander and Pazirandeh, 2019).

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Although collaboration is considered critical for innovation in construction (Loosemore, 2015), several systemic barriers to collaboration remain. The traditional project-oriented structure poses major barriers to diffusion of knowledge and innovation (Blayse and Manley, 2004). Besides, fragmentation and instability of stakeholder relations in projects prevent successful uptake of innovation (Van Oorschot *et al.*, 2020). Considering these barriers, a shift is required beyond single organizations to establish the right conditions for dealing with the societal challenges on a systemic level.

Dealing with these challenges and barriers requires efforts from all actors involved, as well as new concepts or perspectives that help to understand the complex collaborations needed for innovation. A promising concept is the innovation ecosystem (Thomas and Autio, 2020). Pulkka *et al.*, (2016) have effectively shown the applicability of ecosystems in construction projects and networks, which is so far the only systematic study on the ecosystem concept in construction. In this paper, the application of the innovation ecosystem concept in a construction context will be explored, considering network relations on a project-transcending level. To this end, theoretical innovation ecosystem characteristics are applied to two cases in the Dutch construction sector. As such, it is studied whether and to what extent the concept could contribute to the shifts towards a systemic, project-transcending approach to collaborative innovation in construction to deal with the challenges ahead.

Theoretical background

Innovation in the Construction Sector

In the construction context, innovations are often single elements in largely conventional end-products. In addition, given the context-dependency and unicity of construction projects, end-products often consist of many tailored solutions to context-dependent project requirements. Innovation is considered to be a collective act (Iansiti and Levien, 2004). Even if a particular novel technology or process is developed by a single organization, it is affected by the context in which it is implemented, while affecting society in turn. In such an innovation process, the innovating organization is but one actor in the network that affects the construction project. The network includes, next to the supply chain, for example, interest groups, standardization bodies, governmental agencies and financiers (Bygballe and Ingemansson, 2014). Hence, there is a need for a more comprehensive perspective on how systems deal with collaboration and innovation.

The Innovation Ecosystem Perspective

The innovation ecosystem perspective deals with the overarching multi-actor view on innovation. Since the late 1990s, the ecosystem concept found its way as an approach to describe organizational systems. This is particularly - and analogously to the rooting ecology domain - because of the concept's strong emphasis on the interaction between system elements and the system's environment (Tsujimoto *et al.*, 2018). Considering the extensive reviews of Scaringella and Radziwon (2018), Tsujimoto *et al.*, (2018) and Thomas and Autio (2020) on the many approaches to the ecosystem concept, the innovation ecosystem perspective seems to be particularly useful in supporting innovation and change to align the level of complexity of projects with the complexity of the socio-institutional context (Walrave *et al.*, 2018).

Innovation Ecosystem Characteristics

Extant literature on innovation ecosystems focuses primarily on organizations around single value propositions in a rather continuous process flow or around a particular

platform. However, in public project-based sectors, such as construction, conditions for collaboration are different. Value creation is usually organized in projects in the shape of temporary cross-firm organizations in which different stakeholders have conflicting interests (Olander and Landin, 2008). Project- or asset-transcending perspectives on collaboration and innovation in construction are scarce. To explore the applicability of innovation ecosystems to the construction context, a theoretical foundation is required. Inspired by the ecosystem characteristics proposed by Thomas and Autio (2020), the concept is operationalized by four characteristics to understand how the cases relate to the innovation ecosystem perspective.

Involvement of heterogeneous actors

Ecosystem networks tend to exhibit high levels of actor heterogeneity (Thomas and Autio, 2020). The actors, their roles and interlinkages within the network change constantly, resulting in a dynamic network in which actors collaborate complementarily to the value proposition (Valkokari, 2015). The participant heterogeneity displayed by ecosystems can extend to cross-industry networks and transcends the boundary between public and private sectors (Thomas and Autio, 2020). This network may involve the full quadruple helix, including government, market, societal and research actors. As such, the collaboration in ecosystems transcends regular construction participants, such as contractors, clients, and engineering firms, and may include actors from industries, such as material suppliers, technological innovators or other specialized firms that might improve construction products or processes.

Strategic alignment of actors

Ecosystems are characterized by cooptation (Bacon *et al.*, 2020). Cooptation can be understood as the collaboration of actors that operate in each other's competitive areas through alignment of incentives, which creates interdependencies. This interdependency can, according to Thomas and Autio (2020) be viewed from three perspectives. First, a technological perspective where actors involved are co-specialized. An example in construction is the interdependence between suppliers of windows and window frames. Second, an economic perspective where benefits that an actor gains from participating in the ecosystem depend on the simultaneous availability of compatible offerings by other participants. In construction, this can be exemplified by the interdependency between client and contractor in executing a construction work. Third, the cognitive perspective, where the ecosystem network is structured by social rules, assumptions, values, beliefs and practices (Adner and Kapoor, 2010). Such interdependency may arise when actors within a network develop a shared identity as a group. Given these interdependencies, actors develop strategies to align innovation and collaboration processes and to establish a position within the network (Visscher *et al.*, 2021).

Alignment with respect to value proposition

Innovation ecosystems are centred around one or several value propositions (Adner, 2016). As such, the effort of the individual participants towards certain envisioned outputs must be aligned. This can be regarding certain product platforms in which several actors add parts that, together, constitute the end-product, such as a group of heterogeneous participants that together deliver an industrial modular housebuilding concept. Nonetheless, this can also be less-structured contributions in terms of knowledge, ideas, resources, and physical parts. The purposes, knowledge flows, engagement rules and the actors' contributions need to be aligned among the ecosystem participants to achieve such outputs (Adner, 2016). Next to innovations as

novel products or processes, novel business models can be outputs of ecosystems too (Autio and Thomas, 2018). Here, the participation in the ecosystem that introduces a new business model creates competitive advantage over actors outside the ecosystem. Together, the diverse combination of stakeholders incorporates a wealth of ideas, perspectives, and knowledge. This is particularly useful to explore problems and solutions and to maintain a wide solution space. Therefore, ecosystem outputs are both unpredictable and beyond the capacity of single actors yet shared among actors.

Non-formal governance

The strictness of the requirements to participate in ecosystems vary from basic rules to strong control or formal agreements. Generally, relations and governance of actors and actions are largely non-contractual and may change over time (Jacobides *et al.*, 2018). In public construction, procurement law poses barriers to forming long-term and informal relationships, particularly between public clients and private parties (Kuitert *et al.*, 2019). A less-formal governance allows participants to take dynamic roles in the venture towards the value proposition. Rather than being directed by a leading actor, participants may, in contrast to, e.g., formal supply chains, act independent (although being interdependent). System boundaries are blurry because of this relatively informal and dynamic structure (Phillips and Ritala, 2019), and actors might change their intensity and period of involvement and their relations with others. This can be regarding the development of particular components as part of the overall value proposition, the relevance of particular knowledge, or an actor's changing interests or changing contextual factors. These collaborative and interdependent changes towards fulfilment of a value proposition, including actors, activities, relations, institutions, environment, and legislation, are explained through the concept of coevolution (Gomes *et al.*, 2018).

RESEARCH CONTEXT AND APPROACH

To explore the applicability of the innovation ecosystem concept in construction, the cases of the Waterschapsbedrijf Limburg (WBL) and of the Collaboration in asphalt Applications with LIGNiN (CHAPLIN) were analysed because of their project-transcending approach to collaboration and innovation.

WBL is the executive organization of two waterboards in the Netherlands and is responsible for the regional wastewater treatment. To do so, WBL created in 2017 and 2018 a network around their asset-portfolio by dividing the portfolio into five parcels. For each parcel, three contractors were formally contracted in a framework agreement for a period of four to six years and these contracts will end between 2021 and 2024. Next to the parcels, a so-called "shopping mall" was set up, which consisted of a catalogue of multiple technological solutions provided by various suppliers. WBL could directly draw from this through the contractors to promote standardization. This framework agreement in combination with the "shopping mall" enabled WBL to collaboratively seek for the best solutions utilizing the expertise of particular actors. The WBL case is selected for this research as it represents collaboration on a project-transcending level in which multiple actors are involved. Unique for the construction industry, but in line with the innovation ecosystem concept, is that co-opetition is central in this network and the actors involved collectively strive for a certain outcome: a process innovation on collaboration and a product innovation on modularity of wastewater treatment plants.

The CHAPLIN case represents a programme driven by a platform around a collective aim to develop and commercialize lignin biobased asphalt, including research,

development, and pilots. In line with innovation ecosystems, the programme revolves around a central value proposition - the development of lignin biobased asphalt. The network consists of 22 different organizations, such as governments, knowledge institutes, contractors, and suppliers. Unique for the construction industry is that the CHAPLIN network is based on informal relations which are dynamic and change over time, whereby organizations from non-construction sectors are involved.

Case data was obtained through desk research, by attending network events and by conducting interviews. Extensive semi-structured interviews were conducted with the framework agreement manager and contract manager from WBL, and with a manager in one of the contractor companies. After data collection, first, the cases were systematically analysed using the four characteristics introduced in the theoretical background section, resulting in a broad and divergent list of ecosystem characteristics present in these cases. After this analysis, the researchers sought for the typical characteristics that are unique for the construction industry and were explainable as a consequence of the application of the innovation ecosystem concept in this sector. Next, the most striking aspects were studied per case. Finally, the potential opportunities, benefits, and challenges of the application of the innovation ecosystem perspective in the construction industry were explored.

RESULTS

Involvement of Heterogeneous Actors

In the WBL case, both the framework agreement and the "shopping mall" were initiated by WBL, who organized public tender procedures to select participants. This resulted in a heterogeneity comparable to regular construction projects. Yet, the actors were involved throughout the entire construction processes rather than only specific phases to safeguard an integral approach to the potential solutions, and the possibility to select suppliers through subcontracting ensured access to organizations outside the framework. Contrarily, the network in the CHAPLIN case exhibited a high level of heterogeneity. Organizations were able to join the network on their own account, enabling them to act in different roles with respect to the central value proposition. In both cases, non-conventional contractors and suppliers were involved, of whom the intensity of involvement varied over time. In conventional construction projects, contractors in the construction industry team up with suppliers from a rather fixed group, based on, among other aspects, past performance, geographic boundaries, and existing relationships. Nevertheless, in the WBL case this change was managed by WBL, while in the CHAPLIN case the change evolved naturally. Yet, this allowed both cases to adapt to the changing system demands.

Strategic Alignment of Actors

Both cases involved a high level of actor interdependence. In both networks, knowledge sharing was a central element and the actors in the network were dependent of the outputs of other actors in the development and optimization of the product or process. In the case of WBL, actor interdependency was premediated and contractually arranged with agreements on knowledge sharing and developments. In contrast, the interdependency between actors in the CHAPLIN case emerged as a result of the joint development of the biobased asphalt. The construction industry depends in many subsectors on only a few parties per specific component.

For example, viaduct clients in the Netherlands are dependent on only two suppliers that can deliver large pre-cast girders.

Table 1: Case analysis based on four characteristics of an ecosystem

	WBL	CHAPLIN
<i>Involvement of heterogeneous actors</i>	Broad network consisting of actors comparable to regular projects Framework agreement and "shopping mall" that enables project-specific task-actor fit Contractors and suppliers actively involved along all project phases Team composition depends on the type of work in the parcel	Cross-industry collaboration Quadruple helix involved representing a broad diversity of organizations Dynamic network enabling specialized and non-construction actors to participate Aiming for international collaboration
<i>Strategic alignment of actors</i>	Coopetition by contractors and suppliers within framework contract Co-creation in early project stages Deliberate knowledge sharing Trust and collaboration as a basis for distribution of work between contractors Increased overall process efficiency results in aligned incentives towards collaboration	Coopetition and cross-sector collaboration Actors involved from varying backgrounds and varying specialisms, each contributing a "piece of the puzzle" Collective knowledge development and distribution Knowledge development as input for pilots and vice versa
<i>Alignment with respect to value proposition</i>	Project delivery with lower failure costs Increased efficiency through accelerated and circumvented processes (Sustainable) innovation Wide (non-contractual) solution space Technological standardization Knowledge on collaboration, technology, and processes Strong business case for both client and contractors through alignment of incentives regarding value proposition	Contribution to SDG's Sustainable innovation (bio-based road pavement) Knowledge development on bio-based asphalt Potential future competitive advantage Potential for large-scale value capture in future Potential formation of new markets and supply chains
<i>Non-formal governance</i>	Governance formalized in collaboration-oriented framework contracts for 4 to 6 years Framework agreements aimed at particular types of work, resulting in multiple sub-ecosystems Knowledge sharing contractually embedded WBL as orchestrator of the ecosystem. Mediation by external party Boundaries between contractors in framework are blurry; Contractually unspecified amount of work	Non-contractual relations quasi-formalized in voluntary consortium Participation in ecosystem by formal and informal networking Ecosystem boundaries are blurry and dynamic Commitment to make effort CBBB as orchestrator of the network Pilot projects are partly contractually formalized Funds both through participants and subsidies

Given this inescapable interdependence, in both cases alignment of incentives contributed to collaboration by turning competitive relations into cooperative relations. The WBL case demonstrated the benefits of a collaborative attitude in their framework agreements in which project-transcending challenges were included, resulting in opportunities for standardization, novel wastewater treatment plant systems and wider innovations. At the same time, lower costs of failure, lower project durations and pleasant collaboration processes were achieved.

Alignment with Respect to Value Proposition

Central to the innovation ecosystem concept is a common purpose which results in aligned incentives. In the CHAPLIN case this purpose was a sustainable innovation that could deliver future competitive advantage for the contractors and helped public clients with achieving societal challenges and to create public value. This goal was clearly defined by the non-profit organization who initiated the platform.

In the WBL case, this was achieved by changing the cost and benefit structure. By replacing an output-driven contract with a collaboration-driven contract where profits and risks were shared fairly, it was in everyone's interest to deliver a "good" end-product for the lowest costs possible. As such, the output of the WBL parcels continually adapted to current challenges and was a result of both the WBL mission as the knowledge of all participants of the parcel. While the output in the CHAPLIN case - development and commercialization of lignin-based pavement - was clearly predefined, the output in the WBL case was less clearly delineated and rather comparable to the output of regular projects in the wastewater treatment sector.

The CHAPLIN case offered a clear example of an output that would have had little chance in a conventional construction project context, since it would have been difficult to reach and involve the various industries that each delivered a part of the puzzle to the value proposition for single application. The shared value proposition was, as such, the connection between the parties that were involved in the CHAPLIN network. In contrast to regular construction projects, this allowed the innovation trajectory to evolve in a rather explorative way. While the physical output of the WBL case was not so different from regular outcomes in the sector, the changed organization and longer-term collaboration contracts resulted in fundamental changes in processes, which resulted in lower costs of failure, lower project durations, pleasant project collaborations, as well as favourable conditions for innovation.

Non-Formal Governance

Innovation ecosystems are characterized by a loose and informal way of governance - or self-organizing capacity. Given the dependency on public funds in the construction sector and the accompanying procurement law, this informal governance is not easily achievable. Nevertheless, contracts can be shaped in many ways with many different degrees of freedom for the actors involved. In the WBL case this was achieved by contracting several contractors for a fixed period with a partially unknown assignment. Within the boundaries of this contracted period, the formality was rather low and the collaboration largely trust-based, which offered space for the participants to utilize their specific knowledge and unique capabilities. The framework agreement manager noted that a shift of mind-set from wariness (relying on contracts) to trust (relying on good intention) has been a continual and precarious challenge, particularly since it contradicts traditional practice. In the CHAPLIN case, the platform structure allowed participants to join and leave the consortium and to contribute at specific times on specific parts. Here, the structure was informal and largely non-contractual. However, the individual pilot projects in which the lignin was applied in pavement were more organized as conventional projects and hence employed a more formal management and governance structure.

DISCUSSION

The results in the previous section reveal similarities and differences between two cases of novel approaches regarding project-transcending collaboration in the Dutch construction sector. Both cases revealed similarities with core characteristics of the

innovation ecosystem, in particular the alignment of incentives towards a common goal, strong focus on collaboration and complementarity of the various actors involved and low level of (top-down) governance within projects. The diversity and plurality of actors was larger than in conventional projects, which can be a potentially valuable source of radical innovation in construction. Particularly the CHAPLIN case showed how the involvement and trust-based collaboration between industries creates innovative business value beyond single projects, but also in the WBL case a way was found to deal with procurement regulation and gain access to a wider pool of organizations simultaneously. Moreover, the fair distribution of risk and profits in the WBL case showed benefits of trust-based collaboration, which is known to be an important condition for innovation (Lloyd-walker *et al.*, 2014).

In contrast to traditional projects, where power lies primarily at client organizations and where innovation and change is constrained by rigid rules and legislation (Briscoe *et al.*, 2004), both cases reveal a more equally distributed and larger degree of freedom for innovative solutions for the actors. In consonance with the findings from Pulkka *et al.*, (2016), it shows that the innovation ecosystem concept can be beneficial for analysing and organizing value creation in the construction context. However, where the cases studied by Pulkka *et al.*, (2016) are primarily fixed, market-driven networks aimed at a specific physical end-product as purpose, this study emphasizes dynamic networks with a project-transcending character aiming for more abstract purposes. Next to value creation, this study shows that the innovation ecosystem concept is promising as a strategy to foster innovation and facilitate collaboration required to deal with the societal challenges. It seems that particularly the project-transcending character enabled participants to invest in longer-term relationships. Especially in the WBL case, this was visible in the tendency of the contractors to contribute to standardization of wastewater treatment plant components, where in regular construction projects standardization is often resisted by market parties, for it limits their opportunities to differentiate and hence might restrict competitiveness.

Furthermore, studies by Leviäkangas *et al.*, (2016) and Davies *et al.*, (2014) have explored the ecosystem concept in construction and infrastructure. Despite the benefits of such approaches in terms of alignment of incentives and offering the right conditions for innovation, the temporality is limited to that of an asset or (project) organization. The cases studied in this research show that the long-term relationships are particularly valuable for achieving change and innovation in line with the societal challenges. Therefore, the innovation ecosystem approach could be valuable in contributing to the long-term challenges the construction industry is facing. Although we do not expect fundamental differences in applicability of the ecosystem concept outside the Netherlands, it could be worthwhile to explore further cases also outside the Dutch context.

CONCLUSION

In this research, the adoption of the innovation ecosystem concept is proposed as an approach to enable long-term collaboration to provide the conditions for innovation and change, required to enable the construction industry to deal with the upcoming societal challenges. The aim of this research was to explore the application of the innovation ecosystem concept on a project-transcending level by analysing two unique cases. Four ecosystem characteristics were used for this analysis. It was found that underlying principles of the innovation ecosystem perspective can already be found in the industry, particularly the alignment of project-transcending incentives towards a

shared value proposition. To bring this concept further, the conceptual development of the innovation ecosystem concept to fit construction is required. By exploiting these traits in the future, the innovation ecosystem concept could contribute to the shifts towards an integral and project-transcending approach to collaboration to provide the conditions needed for a construction industry in transition.

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