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Strategies promoting innovation in sustainable neighborhood (SN) projects – Lessons from complex and mega projects

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Abstract

Statistics of GHG emissions and energy consumption are continuously reminding us of the urgent drive to promote environmentally sustainable urban neighborhoods and communities. Sustainable neighborhoods are increasingly becoming more popular since they offer opportunities that could be exploited in the change towards a low carbon society. This paper draws on innovation and project management literature in an attempt to describe the strategies and practices promoting innovation during the different stages of the sustainable neighborhood (SN) projects' lifecycle, and illustrate how the project communicates innovation with its wider ecosystem. Moreover, we argue that sustainable neighborhood (SN) projects tend to have an ambidextrous nature, adopting different exploration and exploitation strategies in the front-end and back-end stages, respectively.

Keywords: sustainable neighborhood; innovation; construction innovation; complex projects

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1. Introduction

Statistics of GHG emissions and energy consumption, whether locally or globally [1-3], are continuously reminding us of the urgent drive to promote environmentally sustainable urban neighborhoods and communities. Incorporating sustainability-related aspects in the development process of neighborhood-scale projects represent an opportunity to solve complex societal and environmental problems. This includes, but not limited to, environmentally-friendly design, community energy systems, innovation-oriented solutions, sustainable mobility, sustainable construction materials, and community engagement. Sustainable neighborhoods are developed through a project-based process, passing through different stages before reaching their end: 1) conceptualization, 2) planning, 3) execution, and 4) closure [4]. Community needs and potential stakeholders are usually identified in the conceptualization stage. In the planning stage, detailed plans are agreed before contractual arrangements come into effect, while the actual work is performed in the execution stage. Closure happens when the project is completed and delivered to future residents. However, unlike other building projects, sustainable neighborhood projects incorporate a wide variety of stakeholders.

Several studies have reported how stakeholders in sustainable neighborhood (or SN for simplicity) development projects tend to have different perceptions and interests [5, 6], where vested interests and coordination difficulties can potentially influence and even hamper innovation. This motivates further exploration to understand how innovation can be successfully incorporated in the development process of SN projects. Nevertheless, few studies in the context of SN developments, to the author's knowledge, are found dealing directly with innovation-related issues, see, i.e., [6, 7]. This indicates that literature on SNs seems to lag behind other fields when it comes to fostering innovation in a project environment, see i.e., complex projects [8, 9]. Inspired by the literature on complex projects, here we see an opportunity to improve the planning and construction practices in SN projects. This paper attempts to investigate the strategies and practices promoting innovation throughout the different stages of SN projects' lifecycle.

A foundation to guide future empirical research on promoting innovation in SN projects is proposed by providing two contributions. First, a set of 12 strategies and practices spread over the project lifecycle are described. Second, the project lifecycle in this context is conceptualized as having an ambidextrous nature. The paper is structured into five main parts. In the following part, we examine several streams of literature to understand innovation in complex projects. Part three explains our research approach. Next, we present and discuss innovation in SN projects. Lastly, part five summarizes the study's conclusions and provides suggestions for further research.

2. Relevant literature and theory

2.1. Innovation in the construction industry

Schumpeter [10] defined development as 'carrying out of new combinations,' where the adoption of new means in production can drive economic growth. In the Schumpeterian sense, our understanding of innovation can be linked with the introduction of new materials and methods. However, new is not always the case, and innovation can also be seen as a "recombination of old ideas, a scheme that challenges the present order, a formula, or a unique approach which is perceived as new by the individuals involved" [11]. For example, ideas, products, technologies, methods, and routines that are "perceived as new by an individual or another unit of adoption" [12], such as project setting, fall under the innovation umbrella. Innovation scholars distinguish between innovation and invention [11, 13], in the sense that innovation stretches to include the actual use or commercialization of new ideas. In other words, innovation must be something useful. Scholars have also distinguished between different types of innovations – for example, process and product [14], technical and administrative [11], technical and organizational [15, 16], and product and business process innovation [17]. Within the construction industry, Slaughter [13] defined innovation as "the actual use of a nontrivial change and improvement in a process, product, or system that is novel to the institution developing the change." According to Utterback and Abernathy [14], product innovation is "a new technology or combination of technologies introduced commercially to meet a user or a market need," while process innovation can be defined as a new development in "the system of process equipment, workforce, task specifications, material input, work and information flows, etc. that are employed to produce a product or service".

In an attempt to understand construction innovation, many scholars have investigated the drivers of innovation in the construction industry, see, i.e., [15, 18], including environmental pressure, networking, procurement methods,

clients, and organizational capabilities. Project-based firms operate within the construction industry have increasingly faced new challenges, since "rapid changes in the economy and society are creating demands for new types of buildings and structures" [9]. This means that building a high-quality built environment is becoming more sophisticated [19], especially in the wake of sustainable development goals, and therefore, besides new products and technologies, novel methods and processes are also required. Although both types of innovation, product, and process, are required in the context of SN projects, previous research shows that sustainable building is not hindered by a lack of technologies, but is instead affected with organizational and procedural difficulties [20]. In other words, new processes and methods are inevitable to mitigate the risks and unforeseen costs when introducing new technologies.

Nevertheless, since the current literature on SNs lacks in-depth studies conceptualizing the innovation process, we decided to investigate other streams of research searching for relevant concepts and transferable knowledge. In this sense, the literature on mega- and CoPS projects are found worth exploring for this study.

2.2. Innovation in complex projects

Simon [21] defined a complex system as "a large number of parts that interact in a nonsimple way." Complexity in projects can be characterized by the number of different parts, the degree of interaction between those parts, and the number of hierarchical levels in the system [22-24]. Projects can have varying degrees of complexity, "ranging from relatively simple components and subsystems to more complex systems and systems of systems projects" [23]. In the following, selected literature on complex projects is reviewed, searching for innovation-enabling strategies and practices. In which, we investigate innovation in complex products and systems (CoPS), before moving to the more specific case of megaprojects, as an example of the largest type of CoPS.

Complex products and systems (CoPS) can be defined as "high cost, technology-intensive, customized, capital goods, systems, networks, control units, software packages, constructs and services" [25]. This definition infers that the creation of significant CoPS involves a large number of firms, and tends to be produced in one-off projects to meet the requirements of specific customers [26]. According to Hobday et al. [25], simplifying strategies and mechanisms are essential to cope with the increased complexity, whether it was at the product, technology, or organization level. The standardization of previously customized components serves as an example for simplifying strategies. It allows for innovation, cost reduction, and learning. Hobday [26] examines the various organizational choices when producing CoPS, mainly project-based organization (PBO) and project-led organization. PBO is an organizational form that has potential to foster innovation and is found suitable to the production of CoPS due to its ability to create and re-create new organizational structures and strategies tailored to the demands of each project and customer needs, and its ability to integrate different types of knowledge and skill. However, PBO is inherently weak in coordinating processes, resources, and capabilities across the organization as a whole. This weakness can be mitigated through deploying a project-led organization arrangement, which is found conducive in coordination and resolving problems across the organization. In essence, several aspects must be considered before deciding on an appropriate form of project organizing to match the product mix in question, such as scale, complexity, and customer needs.

According to Davies and Brady [27], project capabilities refer to the activities, knowledge, and skills required to manage the preparation and production of CoPS in one-off nature to meet customer demands and expand successfully into new products and services. They cover activities such as requirements gathering, conceptual design, cost estimation, risk management, tendering, and other project management tools. In their recent work, project capabilities can be used "to explore innovative new possibilities and deal with rapidly changing and uncertain conditions, and also to exploit current routines and perform repetitive processes when conditions are stable and predictable" [8].

Flyvbjerg [28] defined megaprojects as "large-scale, complex ventures that typically cost US$1 billion or more, take many years to develop and build, involve multiple public and private stakeholders". Although major urban development projects, i.e., SN, do not necessarily meet the US$1 billion criteria, they may share some of the remaining features of megaprojects. Drawing on London Heathrow Terminal 5 project, Davies et al. [29] identified two categories of innovation in the production system that improve megaproject processes: system recombination and replication. Innovative recombination involves learning (about successful ideas, best practices, and technologies) from previous projects or other industry settings, and combining them to improve performance. At the same time, replication intends to create a universal approach that can be reused in future projects by learning how to alter and improve the current combination of processes.

In another British megaproject, London's Crossrail railway system, Davies et al. [30] identified four windows of opportunities to intervene and promote innovation in megaprojects: bridging, engaging, leveraging, and exchanging. The bridging window takes place during planning at the very project front-end. During this window, similar to recombination, the potential of successful practices, technologies, and organizational processes from other projects or industries are investigated and integrated. Learning can also facilitate the selection (or development) of appropriate organizational structure and governance. Engaging window focuses on preparation for tendering and contracting. Here the project can develop new ways of tendering and contracting. For example, a reward system encourages the adoption of innovative solutions, or a tender method allows the early involvement of potential project stakeholders. During this stage, strategies and processes are developed to identify and resource innovations across the project supply chain. An example from the Crossrail project is when the innovation team used online tools to identify, develop, and broker successful ideas across the project. The last window, exchanging, occurs after project completion, and involves the connection with the broader project ecosystem to share and trade innovations.

Reviewing the literature on complex projects allowed us to understand the characteristics that set them apart from other traditional projects. The identified strategies (Table 1) will be discussed later in-depth in an attempt to understand how innovation occurs in SN projects.

Table 1. Innovation in CoPS and Megaprojects.

Project type (Source)	Characteristics	Innovation-enabling strategies
CoPS projects [9, 25-27]	-Complex products and systems, high cost, technology-intensive, "the backbone of the modern economy," extreme production and innovation complexity, the exact opposite of mass production, unpredictable events and interactions, system integration -Examples: flight simulators, aircraft engines, baggage handling systems, etc.	-Simplifying strategies -Project organizing -Building project capabilities -Economies of repetition -User involvement
Megaprojects [23, 29, 30]	-Massive investment ($1B or more), Infrastructure projects, "performance paradox" or "megaproject paradox," system integration model, complex projects (system of systems), multi-actor decision-making process, conflicting interests. -Examples: airports, cities, metros, etc.	-System recombination and replication -Bridging (seeking and integration of practices and processes from previous projects and related industries) -Engaging (new ways of tendering and contracting) -Leveraging (identifying and resourcing innovations across the project supply chain) -Exchanging (Sharing and trading innovations on the broader project ecosystem)

3. Illustrative examples of innovation in SN projects

Innovation in the context of sustainable housing and neighborhood projects seems to be an understudied phenomenon, as the current literature, to the author's knowledge, tends to focus on aspects related to sustainability, policy, and citizens, and lacks a conceptualization of how innovation occurs during the project. As illustrated below in Figure 1, we opted to approach the research query from two perspectives. Our prime point of departure was the literature on construction innovation and complex projects, before using illustrative examples from the literature on SN based on real-world projects.

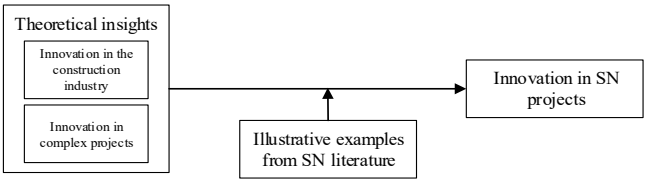

Figure 1. Analytical framework.

Seven empirical studies were chosen from the literature on sustainable housing and neighborhoods (as illustrative examples) to demonstrate how innovation is applied in this context. The selection of these papers was based on whether they discuss strategies and practices promoting innovation in SN projects. [31] uses a case study that relies on a building project, but we chose it due to its valuable insights on procurement issues. Table 2 outlined the main takeaways from each paper. Some of the above examples have similarities in the kinds of innovations implemented. For example, both [6] and [32] show the importance of creating new ways of governance, while [7] and [33] show the importance of learning and knowledge sharing practices through the use of a broad mix of tools.

Table 2. Illustrative examples.

Article	Description and types of innovation
[6]	Innovative governance models are required to manage and run the new community energy system.
[7]	Various explorative and exploitative tools were used in the planning of energy ambitious neighborhood projects.
[31]	A more interactive procurement process and a new contract model were used to improve innovation and building quality.
[32]	A new method, 'Planning the Village Area as a Whole,' was used to prepare the land for the project.
[33]	The project implemented a broad mix of innovative practices, activities, and tools supporting joint learning.
[34]	Cooperatives and cooperative networks acted as a source of organizational innovation.
[35]	Innovative public procurement is shown to be an attractive governance tool that could potentially manage complexity in SN projects.

4. Towards an understanding of innovation in SN projects

4.1. Strategies and practices promoting innovation in SN projects

In our attempt to understand how innovation happens in SN projects, it has been necessary first to understand how it happens in other project-based contexts. In the following, we extend the work of Davies et al. [30], and the notion of innovation windows to describe strategies and practices promoting innovation in SN projects, see Table 3.

Following Davies and Brady [8], project capabilities can be used at the outset of the project or in the bridging stage, especially in times of uncertainty, to explore new possibilities and methods before proceeding to formal planning or implementation. We see this explorative behavior in Valkering et al. [33], where the project implemented a broad mix of activities and tools supporting joint learning, such as project coordination, site visits, project's webpage, knowledge exchange platform, and thematic meetings. In Nielsen et al. [7], the involved stakeholders implemented explorative and exploitative innovation process tools. Explorative process tools were applied early in the project, such as stakeholder workshops, better integration of energy into urban planning, visualization, and incremental learning. Furthermore, we see examples of recombining in [33] when the project benefited from exogenous experiences applied in other places, in which relevant practices are first identified, then transferred to the project. The bridging stage, as a free-contract zone, is most appropriate to import and upgrade known experiences since it has much room to influence the final project results [4]. However, we argue that absorbing other practices into the project is something that could also be done through the other stages of the project lifecycle, yet in a less explorative mode.

The engaging stage in complex construction endeavors, such as SN projects, calls for integrated modes of collaboration, relationship management, early involvement of potential project stakeholders, and procurement systems that encourage the adoption of innovative processes and products [15]. SN projects are not necessarily owned or managed by one entity, and thus PBO can be a single or multi-firm alliance. This points to the importance of choosing a suitable form of organizing and governance in SN projects. For example, cooperatives and cooperative networks are powerful organizational forms in sustainable city development and very suitable for diffusing new knowledge [34]. New governance models are required to balance social equity against the need to ensure the economic viability of the introduced new systems [6]. Zhan and de Jong [32] show how new forms of public-private partnerships (PPPs) are designed and implemented in a way to balance the interests of different stakeholders, such as 'Planning the Village Area as a Whole' method. The method welcomed residents as investors and reduces government expenditure on land acquisition. Moreover, innovative clients, who demand new requirements and higher standards, can influence the procurement and supplier selection processes as it is in the project's best interest to choose partners who are willing to innovate and cope with unforeseen changes [15, 18]. According to Hamdan and de Boer [35], conducting a dialogue with suppliers during the pre-tender stage offer various benefits, including needs mapping, improved specifications, access to supply market, market visibility, market collaborations, that could potentially be used to reduce some of the structural complexity and uncertainty imposed on SN projects. In another study by Sparrevik et al. [31], a new contract

model, hybrid-turnkey contract, placing more weight on the upfront work (design), was applied to improve building quality, lower operational cost, and reduces construction errors in a net-zero energy building project.

Table 3. Promoting innovation in SN projects.

Stages of the project lifecycle	Strategies and practices
Bridging (Conceptualization)	-Building explorative project capabilities
	-Recombining of innovative tools, products, and practices from other projects or industries
	-Building relationships and networking with the broader project ecosystem
	-Integrating the needs of clients and following positive pressures
Engaging (Planning)	-New forms of organizing and governance
	-New ways of tendering and contracting
	-Selecting innovation-oriented project partners
Leveraging (Execution)	-Exploiting organizational capabilities
	-Spreading innovations across the project supply chain
Exchanging (Closure)	-Exporting innovations on the broader project ecosystem
	-Reusing (replicating) successful practices on similar projects
	-Economies of repetition

Adapted from [29, 30]

In leveraging, firms involved in project delivery can use capabilities to create a favorable climate for innovation during the design and construction, such as competencies, key individuals, and flexibility [15, 36]. That is, greater flexibility allows housing developers to think innovatively while achieving ambitious standards. For example, Davies et al. [30] described how the Crossrail megaproject utilized an organizational mechanism for identifying and resourcing innovation across the supply chain. The mechanism built upon online tools to submit ideas (innovation portal), report on the progress of ideas (innovation management system), and share innovations across the project community. In Valkering et al. [33], the created learning network between neighborhoods encouraged innovation through collective learning and knowledge sharing, in which internal actors used tools, such as the online portal, as a way to spread useful knowledge and innovative practices across the whole project. In essence, knowledge facilitating innovation in the leveraging window come mainly from three sources: 1) knowledge recombined from other industries or projects during bridging, 2) knowledge developed during bridging, and 3) knowledge brought by project actors during engaging. Developing innovative practices and methods during the leveraging stage is challenging because of contract obligations (i.e., standards) and project constraints (i.e., time). Thus, improvements introduced in this stage follow an exploitative approach rather than an explorative one.

During the last stage, exchanging, project actors have the chance to share their successful, innovative practices with the broader project ecosystem, and pool resources with others to improve those practices even further [30]. The project can also share such knowledge with innovation brokers who can accelerate the diffusion of innovations between organizations working in similar SN projects [15], such as the ZEN research Centre mentioned in Nielsen et al. [7]. Practices that proved to be useful can be modified and refined to create a common reusable approach for future SN projects [29]. The exchanging of innovative practices does not necessarily happen after the completion of the whole neighborhood project; instead, it could happen after the end of its smaller components, i.e., buildings. That is, recycling innovation experience from one building project to another within the same SN development enables firms to develop ‘repeatable solutions,’ and reduce cost through ‘economies of repetition’ [27]. The exchanging window is most appropriate to improve, and export learned experiences to the broader project ecosystem. Nevertheless, we argue that some projects may not wait until completion to share their tried practices and methods since success and failure in SN projects can be multifaceted and hard to measure due to the long development periods.

4.2. The ambidextrous nature of SN projects’ lifecycle

Brady and Davies [37] have described the phases of project-led learning: an exploratory vanguard project phase, a project-to-project phase, and a project-to-organization phase. Here ambidexterity is present between consecutive projects. In the context of SN projects, we note that the project lifecycle seems to have an ambidextrous nature, as strategies applied vary from explorative-oriented in the front-end stages to exploitative-oriented in the back-end stages. Therefore, we argue that ambidextrous behavior can also exist within the boundary of the same project, see

Figure 2. That is, as the project moves toward execution, the degree of exploitation increases gradually at the expense of exploration. Nielsen et al. [7] offer support for our argument. They state that it is challenging to put explorative innovations into use once the projects have reached the implementation stage – due to several challenges, such as moving targets in citizen involvement, regulatory limitations, and conflicting agenda. The authors argue that to bridge the gap between explorative and exploitative approaches, some key players need to become more ambidextrous. However, while this strengthens our claim about ambidextrous behavior in SN projects, we believe that explorative and exploitative innovations do not occur in sequence. Instead, they occur in parallel and with varying degrees during the different development stages.

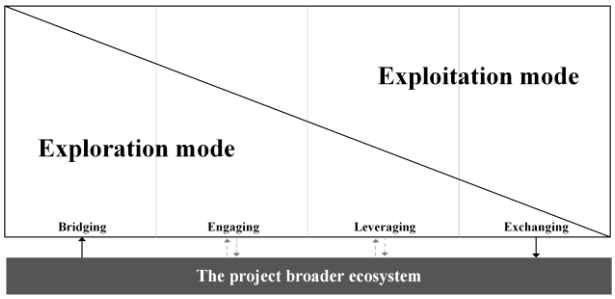

Figure 2. The ambidextrous behavior in SN projects. (Adapted from *Brady and Davies [37]*)

Further support for the above argument comes from the nature of SN projects. Neighborhood-scale projects can be produced either as one large project or divided into several smaller subprojects, using, for example, the notion of project networks [38] or program management [39]. This could also imply that the connection of the project with its broader ecosystem is not exclusive to a particular stage, see Figure 2. For example, maintaining a reciprocal connection with the outside world during engaging and leveraging stages may serve the setting of SN projects, particularly when the neighborhood's components are delivered in multiple interdependent subprojects – i.e., innovations captured or developed by one subproject can be shared with other subprojects.

5. Conclusions

This paper proposes a foundation to guide future empirical research on innovation in SN projects by providing two contributions. First, based on theoretical insights and illustrative examples from the literature on complex projects and SN, the paper discusses a set of 12 strategies and practices spread over the project lifecycle and illustrates how the project exchanges innovation with its broader ecosystem. Second, the project lifecycle in this context is conceptualized as having an ambidextrous nature, in which strategies vary from explorative-oriented in the front-end stages to exploitative-oriented in the back-end stages. SN projects are complex phenomena embedded in a multi-stakeholder environment, yet have the potential to solve societal problems and accelerate the sustainable transition. Thus, we encourage project management scholars to utilize SN projects as an empirical setting in project studies. That is, the knowledge derived from SN projects can be used to advance project management theory, such as project complexity, knowledge management, and construction innovation. Furthermore, future SN research should investigate much in-depth the innovation process and innovative practices used throughout the development stages, and measure their impact on project performance and stakeholder collaboration.

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