

Innovation Ecosystems in the Construction Industry

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I. INTRODUCTION

Abstract—The construction sector is a key driver of the global economy, contributing significantly to growth and employment through a diverse array of sub-sectors. However, it faces challenges due to its project-based nature, which often hampers long-term collaboration and broader incentives beyond individual projects. These limitations are frequently discussed in scientific literature as obstacles to innovation and industry-wide change. Traditional practices and unwritten rules further hinder the adoption of new processes within the construction industry. The disadvantages of the construction industry's project-based structure in fostering innovation and long-term relationships include limited continuity, fragmented collaborations, and a focus on short-term goals, which collectively hinder the development of sustained partnerships, inhibit the sharing of knowledge and best practices, and reduce incentives for investing in innovative processes and technologies. This structure typically emphasizes specific projects, which restricts broader collaborations and incentives that extend beyond individual projects, thus impeding innovation and change. The temporal complexities inherent in project-based sectors like construction make it difficult to address societal challenges through collaborative efforts. Traditional management approaches are inadequate for scaling up innovations and adapting to significant changes. For systemic transformation in the construction sector, there is a need for more collaborative relationships and activities beyond traditional supply chains. This study delves into the concept of an innovation ecosystem within the construction sector, highlighting various research findings. It aims to explore key questions about the components that enhance innovation capacity, the relationship between a robust innovation ecosystem and this capacity, and the reasons why innovation is less prevalent and implemented in this sector compared to others. Additionally, it examines the main factors hindering innovation within companies and identifies strategies to improve these efforts, particularly in developing countries. The innovation ecosystem in the construction sector generates various outputs through interactions between business resources and external components. These outputs include innovative value creation, sustainable practices, robust collaborations, knowledge sharing, competitiveness, and advanced project management, all of which contribute significantly to company market performance and competitive advantage. This article offers insights and strategic recommendations for industry professionals, policymakers, and researchers interested in developing and sustaining innovation ecosystems in the construction sector. Future research should focus on broader samples for generalization, comparative sector analysis, and application-focused studies addressing real industry challenges. Additionally, studying the long-term impacts of innovation ecosystems, integrating advanced technologies like AI and machine learning into project management, and developing future application strategies and policies are also important.

Keywords—Construction industry, innovation ecosystem, innovation ecosystem components, project management.

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THE construction sector significantly contributes to the global economy by fostering growth through a myriad of sub-sectors and generating extensive job opportunities. In numerous countries, the construction industry is crucial for economic development, impacting both local and international spheres. However, its inherent project-based structure presents substantial challenges, such as limited long-term collaboration and insufficient broader incentives beyond individual projects. These constraints are well-documented in the literature and are identified as major barriers to innovation and progress within the industry.

The fragmented nature of construction projects often restricts sustained collaborative efforts, which are essential for addressing societal and environmental challenges. Traditional practices and entrenched norms further inhibit the sector's ability to integrate new processes and technologies. Research underscores the need for a systemic transformation in the construction industry to foster more collaborative relationships and activities that transcend traditional supply chains [1].

Moreover, the adoption of innovative practices can enhance efficiency and collaboration. However, there is a notable gap in the literature regarding comprehensive maturity models that benchmark the integration of these methods. Existing models often fail to capture the full spectrum of benefits that these innovations can bring to the industry [2].

In summary, addressing these challenges requires a concerted effort to shift from traditional project-based approaches to more holistic, collaborative frameworks. This transformation is critical for enabling the construction industry to adapt to and drive innovation, thereby improving overall performance and sustainability.

II. INNOVATION ECOSYSTEM APPROACH IN THE CONSTRUCTION INDUSTRY

In the business context, ecosystems are conceptualized in two prominent ways in the literature. First, ecosystems are seen as dynamic and intentional networks where diverse participants work together to generate value that would be unattainable by any single entity acting independently [3]. Second, ecosystems are described as networks, firms, or platforms composed of interlinked organizations centered around a focal point, creating an interconnected system [4].

In their complementary studies, [5] and [6] delve into the composition of ecosystem-based businesses, elucidating the layers of participants that form their core. They identify three distinct layers of actors within these ecosystems. These layers represent different levels of engagement and value creation,

highlighting the complex interplay between various stakeholders in driving innovation and sustainability within business ecosystems.

It can be stated that the innermost layer consists of core participants who are directly involved in the primary activities of the ecosystem [5]. These actors are crucial for the ecosystem's immediate functioning and include key partners, suppliers, and customers who play a direct role in the value creation process. The second layer includes secondary participants who support the core activities but are not directly involved in the primary processes. These can be ancillary service providers, regulatory bodies, and other organizations that provide necessary support to the core actors. The outermost layer consists of peripheral participants who have a more indirect influence on the ecosystem. These can include industry observers, media, and other entities that, while not directly involved, still impact the ecosystem through their interactions and observations.

The evolutionary nature of business ecosystems should be emphasized. As [6] suggests, ecosystems develop through stages, starting from birth, where the focus is on establishing the core components and relationships, to expansion, where the ecosystem grows and attracts more participants. This is followed by leadership, where dominant players emerge to drive the ecosystem forward, and finally self-renewal, where the ecosystem must innovate to sustain its relevance and competitive edge.

These layers and stages underscore the importance of understanding the multifaceted and dynamic nature of business ecosystems, as they are crucial for fostering innovation, sustainability, and long-term success in an interconnected global economy. By recognizing the roles and contributions of various actors within these ecosystems, businesses can strategically position themselves to leverage collective strengths and drive value creation beyond the capabilities of individual entities.

This study explores the concept of an innovation ecosystem within the construction sector, examining various research findings to understand the components that enhance innovation capacity. The focus is on addressing key questions about how a robust innovation ecosystem contributes to increased innovation capacity and why innovation is less prevalent in the construction sector compared to other industries. The study also investigates the primary factors that hinder innovation initiatives within companies and identifies strategies to improve these efforts, particularly in the context of developing industries.

Through an extensive analysis of existing literature, this research aims to understand and promote innovation and change within the construction sector. The primary goal is to create a sustainable and efficient industry by leveraging the potential of an innovation ecosystem, thereby enhancing long-term collaboration, communication, and overall performance.

III. INNOVATION ECOSYSTEM PROVIDER COMPONENTS FOR CONSTRUCTION BUSINESS

The innovation ecosystem is defined as a network of interconnected organizations centered around a focal firm or platform, involving participants from both production and usage sides, with the goal of creating new value through innovation [3]. A review of national and international literature shows that innovative construction projects benefit from meaningful relationships within this ecosystem. The selected studies systematically address the innovation ecosystem, examining its criteria and root causes. A detailed analysis reveals specific components (indicators) in work environments that can foster an effective innovation ecosystem. Understanding these components is essential for establishing and utilizing the ecosystem effectively. The following sections will explore these components further, supported by relevant academic references.

This study provides a comprehensive analysis of the various research contributions that explore the innovation ecosystem within the construction sector. It draws upon the foundational works of the following: [3], [7]-[10]. The primary aim of this research is to elucidate the critical components that enhance the innovation capacity of the construction industry.

Moreover, the study investigates the intricate relationship between the establishment of an innovation ecosystem and the enhancement of this capacity. Despite the significant potential for innovation in construction, the sector has historically been less proactive in addressing and implementing innovative practices compared to other industries. Consequently, the research delves into the key factors that hinder innovation initiatives within firms, identifying barriers such as organizational culture, lack of collaboration, and insufficient investment in research and development.

Furthermore, the study explores potential strategies to foster and enhance innovation initiatives within the construction sector. By examining these dynamics, this research aims to contribute valuable insights into how the construction industry can better leverage its innovation ecosystem to improve overall performance and competitiveness.

A. Customers and Manufacturers

In the construction sector, both customers and manufacturers play pivotal roles in driving innovation. Customers stimulate innovation by articulating new requirements and demanding enhanced performance and flexibility in products and services. Their technical competencies also significantly impact the innovation landscape, as knowledgeable customers can better assess and influence the development of innovative solutions.

Manufacturers, on the other hand, contribute to innovation by developing and supplying advanced components and products, as well as investing in research and development initiatives. Their commitment to continuous learning and adaptation, coupled with a stable presence in the market, further fosters an environment conducive to innovation. Therefore, the interplay between customer demands and the innovative offerings of manufacturers is essential for promoting innovation within the construction sector [7].

B. Production Methods

In the construction sector, the characteristics of production and management often exert a detrimental influence on innovation. The inherently temporary and project-specific nature of construction initiatives disrupts the development of knowledge and hampers organizational memory, thereby limiting the applicability of innovations to subsequent projects. Moreover, the emphasis on durable structures tends to favor established methods and techniques, which discourages suppliers from diversifying their product offerings. Additionally, traditional management practices, coupled with the predominance of small enterprises with constrained resources, further impede innovative activities within the sector [7].

C. Relationships

In the construction sector, the relationships within the industry play a crucial role in shaping innovation by facilitating the flow of knowledge among individuals and organizations. However, the temporary nature of construction projects can disrupt these relationships, resulting in both hindrances and opportunities for innovation. While construction projects serve as "trial workshops" for testing innovations, they often struggle to effectively transfer this knowledge to subsequent projects.

The establishment of stronger relationships among the various firms and individuals involved in these projects can significantly enhance innovation outcomes. Additionally, innovation intermediaries can further promote innovation by improving knowledge dissemination, particularly with a cross-industry perspective. This approach can help overcome the limitations associated with "technology surveillance" within the construction sector [7].

D. Participation of Heterogeneous Actors

Innovation ecosystems, as described in [11], comprise networks that extend across multiple sectors rather than being confined to a single industry. This characteristic is positively correlated with the emergence of innovative solutions, largely due to the diverse expertise that non-industry specialists contribute to these ecosystems. For instance, in the infrastructure domain, chemical companies may play a pivotal role in advancing construction material innovations, while information technology firms may contribute significantly to digital innovations.

A defining feature of innovation ecosystems is not only their inherent diversity but also their reliance on non-generic complementarities. Actors within these ecosystems provide specific components essential to the overall value proposition by leveraging their unique skills or products. Collaboration within innovation ecosystems transcends the traditional participants typically involved in construction projects—such as contractors, government agencies, and engineering firms—by also incorporating material suppliers, technological innovators, and academic institutions.

In this context, each actor can possess distinctive skills or offerings that enhance the collective value proposition through collaborative efforts. This underscores the critical importance

of inter-sectoral and inter-institutional collaboration and illustrates that innovation is a multifaceted process involving various stakeholders. The multi-layered structure of innovation ecosystems holds the potential to yield more effective and sustainable solutions for both societal and economic development.

E. Governance System

Construction projects function as temporary networks within the broader, permanent networks of firms. The creation of value in these projects is contingent upon the management of tasks and the individuals responsible for executing them. This management process is referred to as "membership control." In permanent networks, membership control typically relies on informal and relational mechanisms, whereas, in construction projects, it traditionally depends on transactional mechanisms. Public construction projects, in particular, may encounter additional constraints regarding participant selection due to public procurement regulations [9].

There exists a close interconnection between temporary and permanent networks. The characteristics of permanent networks can impose limitations on how temporary networks access essential resources. For instance, technical regulations may restrict the number of organizations that can participate in specific projects. Collaboration within permanent networks often translates into collaborative efforts within individual projects; however, temporary networks can also serve as a catalyst for establishing longer-term interactions. The success of past projects is a critical factor influencing future collaborations, particularly in the formation of project-based enterprises between contractors and suppliers.

The temporal dimension is an important aspect of this analysis. The property development process generally encompasses several stages: planning, design, construction, operation, and reuse. The composition and size of the network involved in value creation can evolve throughout these stages. Effective value creation is facilitated when membership control is rigorously managed and appropriately limited.

The construction industry is characterized by the necessity for a strong central organization to coordinate the inputs from various collaborating entities. However, the efficacy of such centralized models is often questioned in contexts where central authority is weak or non-existent. Furthermore, formal contracts address only a subset of the task coordination issues that arise. Many challenges emerge once construction commences, often requiring informal mechanisms such as trust, goodwill, and reputation to navigate. Task coordination plays a pivotal role in enabling value creation through participant cooperation, and informal mechanisms can effectively complement formal coordination strategies.

IV. CONCLUSION

The literature review highlights the importance of innovation ecosystems within the construction sector, emphasizing the interplay between corporate resources and external components. Internal factors, such as production methods, informal communication channels, knowledge sharing,

employee creativity, and project management skills, are essential for fostering innovation processes within organizations.

External components, including regulations, standards, and relationships with customers and suppliers, shape the dynamics of innovation in the sector. Furthermore, technology and digitalization play a critical role in enhancing construction processes through innovative solutions like robotics, artificial intelligence, virtual reality, and big data analytics, which improve efficiency, cost-effectiveness, and sustainability.

The outcomes of these innovation ecosystems manifest at both organizational and sectoral levels. At the organizational level, they lead to innovative value creation, robust collaborations, and increased competitiveness. At the sectoral level, they contribute to the establishment of high-quality standards, improvements in regulations, and overall industry development.

These findings align with existing literature that underscores the pivotal role of innovation ecosystems in driving project success and effective management. The insights derived from this review offer strategic recommendations for industry professionals, policymakers, and researchers aiming to cultivate and sustain innovation ecosystems in the construction sector.

Future research directions should focus on broader analyses for generalization, comparative sector studies, and application-oriented investigations that address real industry challenges. Additionally, examining the long-term impacts of innovation ecosystems, integrating advanced technologies into project management, and formulating effective strategies and policies are crucial for enhancing competitiveness. The construction sector must embrace continuous innovation, emphasizing improved project management competencies, employee creativity, advanced information flow, and increased digital technology utilization to remain competitive in a rapidly evolving landscape. Strategic investments in education, technical infrastructure, and innovative initiatives will be vital for fostering a more competitive, innovative, and sustainable industry.

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