EPiC Series in Built Environment

Volume XXX, 2026, Pages 1–10

Proceedings of Associated Schools of Construction 62nd Annual International Conference

Bridging the Gap: Barriers to Effective Collaboration Between Technology Startups and Construction Firms

Busra Yucel [1], Salman Azhar [1]
[1]Auburn University

Since collaboration with technology ventures has an important potential for the development and adoption of construction technology, identifying the barriers to this engagement is important. This study examines how mid-to large-sized U.S. construction firms engage with technology startups and the barriers that influence these collaborations. Results reveal that purchasing products and licenses represents the most prevalent form of engagement, with companies such as Drone Deploy, OpenSpace, and Join emerging as leading partners due to the maturity and demonstrated benefits of their technologies. The barriers related to these were clustered into four overarching themes: knowledge and fit, organizational/resource constraints, strategic/cultural misalignment, and risk/legal concerns. Among these, knowledge- and fit-related issues were found to be the most critical, particularly the challenges of identifying suitable startups and startups' limited understanding of the construction sector. Conversely, concerns about intellectual property were less significant than in other industries, reflecting the sector's preference for applied technological solutions over proprietary innovation ownership. Overall, the findings suggest that fostering effective corporate–startup partnerships in construction requires improving sector-specific knowledge exchange, enhancing organizational readiness, and developing trust-based mechanisms that enable long-term, strategic innovation collaboration.

Keywords: Construction technology, Startups, Collaboration, Barriers, Startup engagement

Introduction

Over the past ten years, more startups have offered digital solutions for construction, and these companies have attracted more investment in the last few years than before (Regona et al., 2022). Technology startups are naturally innovative, and accordingly, construction companies are engaging with these startups more frequently due to the increasing demand for technology adoption in the construction industry. Corporations engage with startups for various purposes and in different ways, including purchasing products, forming partnerships, and making investments. These relationships help companies adopt new technology and encourage innovation across the whole industry (Bertin & Mavoori, 2024). Such networks help create new partnerships by sharing information (Inkpen & Tsang, 2005), and when different companies and networks work together, it enables innovation by letting them learn from each other, which leads to new ideas (Wang & Hu, 2020). This builds a stronger ecosystem where companies work together toward shared goals (Zhang & Chen, 2021) and combines different types of knowledge (Nissen et al., 2014).

Recently, various approaches have emerged in how companies approach these partnerships. Models such as open innovation (Nduro & Duodu, 2025), Entrepreneur in Residence (EIR) programs, and Corporate Venture Capital (CVC) programs (Laboe, 2023) are gaining popularity as construction companies seek alternatives to traditional service procurement methods. Top construction companies have put many startups through training programs, and these startups have raised over $375 million in funding, showing that these partnership approaches are working well (Antonellis, 2023). These new approaches show a different perspective, where innovation is not just adopted but developed together through partnerships between startups, established companies, researchers, and investors.

Even though partnerships between construction firms and startups are becoming more important, most existing research has focused on either how technology gets adopted or general innovation management principles (Arabshahi et al., 2021; Elkhayat et al., 2024; Khan et al., 2024; Nduro & Duodu, 2025). However, specific ways that established construction companies strategically work with startups and the barriers affecting this partnership have not been evaluated in the construction management literature.

Given this background, understanding these partnerships and identifying the key barriers that prevent successful partnerships is critical for supporting an innovative construction ecosystem, as startups play a unique and important role that differs from that of large technology providers. This research aims to reveal how large and mid-sized U.S. construction firms collaborate with startups to drive innovation, as well as the factors that affect these partnerships from the perspective of established construction firms.

Research Background

For businesses that are seeking to create an innovative and technology-driven working environment, it is inevitable to engage with technology providers, consultants, or strategic partners (Zahoor & Al-Tabbaa, 2020). As a partnership between corporations and technology startups provides different opportunities for both stakeholders, an increasing number of studies have been evaluating the modes of such partnerships in various industries, including pharmacology, information technologies, and supply chain (Bańka et al., 2025; Kalinowska-Beszczyńska & Prędkiewicz, 2024; Wagner, 2021). Such partnership efforts may take several forms and may include financial funding.

Even though it has numerous benefits, research and development collaborations usually come with different challenges, such as coordination and monitoring (Hottenrott & Lopes-Bento, 2016). For example, Turetta and Labiak Junior (2023) have defined several barriers preventing companies from practicing CVC through a survey study with 28 participants. The top three ranked barriers were listed as “legal or judicial questions”, “difficulty in mapping or prospecting startups”, and “the company’s culture”. Similarly, Santa-Maria et al. (2025) focused on sustainability-oriented corporate-startup alliances and evaluated drivers, barriers, and shared resources through eight cases. The partnerships have been through CVC, an accelerator program, and being a venture client. The study identified 14 barriers and listed the top three barriers as “corporate bureaucracy”, “limited startup capacity”, and “lack of corporate entrepreneurial culture”.

On the other hand, no research has identified the barriers preventing construction companies from collaborating with technology startups to drive innovation and technology adoption. Considering the accelerating adoption of technology for gaining and protecting competitive advantage in the sector, identifying the barriers to engaging with technology ventures that enable this drive is crucial for transforming the construction industry environment. Accordingly, this research aims to identify the common partnership modes and barriers to these engagements.

Methodology

The purpose of this study is to examine barriers that shape engagement between construction companies and technology startups, addressing a gap in the literature where such engagement is often discussed descriptively but rarely examined through systematic empirical evidence grounded in organizational and innovation theory. Prior studies have identified challenges related to construction innovation adoption, yet limited empirical work has focused on engagement processes with external technology startups from the perspective of incumbent construction firms. This study responds to that gap by adopting a structured empirical approach to capture both the prevalence of engagement behaviors and the underlying rationales influencing organizational decisions.

Data were collected through an online survey administered to construction professionals with direct experience engaging with technology startups within the past five years. This inclusion criterion ensured that responses reflected recent engagement practices within the contemporary construction technology ecosystem. A purposive sampling strategy was employed to target organizations with demonstrated capacity and exposure to innovative activity. The survey was sent to experts in top construction companies listed in the ENR Top 400 Contractors list via email. This approach enables reaching a relevant participant population (Waddock & Graves, 1997), as the ENR Top Contractors list is a well-known resource in the construction industry, providing a dependable approach (Liu et al., 2018). Following firm identification, individuals occupying senior management, innovation, technology, or operations roles were invited to participate, as these positions are most directly involved in decisions related to startup engagement.

The survey instrument was designed as a mixed-methods tool, integrating structured quantitative items with qualitative open-ended questions. Quantitative components included demographic variables, multiple-choice questions, and ranking items to capture engagement modes, perceived barriers, and startup identification channels. Qualitative components consisted of open-ended prompts and conditional follow-up questions, which were used to elicit deeper explanations of respondents' preferences and decision-making rationales. For example, respondents indicating engagement through pre-market piloting were presented with targeted follow-up questions specific to that collaboration mode.

Survey development was informed by three complementary inputs. First, exploration interviews with three industry professionals provided practice-based insights into common engagement mechanisms and challenges. Second, findings from the academic literature on construction innovation (Yucel & Azhar, 2024), open innovation, and inter-organizational collaboration guided construct selection and question framing. Third, the survey instrument was reviewed by three academic experts to improve content validity and clarity. Quantitative data were analyzed using descriptive statistics and co-occurrence analysis to identify dominant patterns and relationships, while qualitative responses were analyzed through inductive coding to extract recurring themes. The integration of these analytical approaches supports triangulation and enhances the interpretive depth of the findings.

Findings and Discussion

This study utilizes data collected from experts who actively engaged with technology startups in the past five years. For the reliability of the responses, an inclusion criterion is provided to respondents that defines the startup: *"Startups are newly established businesses focused on developing a unique product or service and bringing it to market. They are usually backed by angel investors and/or venture capital. A company can be considered a startup if it generates revenue of less than $100*

million and employs fewer than 500 people. For example, Autodesk and Procore are not classified as startups, whereas Dusty Robotics and Document Crunch are considered startups. If unsure, you may check the company information on https://crunchbase.com."

Table 1 summarizes the demographic information of the 28 participants. Half of the respondents have over 16 years of experience in the construction industry, and most hold a degree in Construction Engineering and Management. Additionally, the majority of respondents occupy senior management or decision-making roles within their organizations. To further contextualize these perspectives, organizational characteristics were also captured. Most participants were employed in mid-to large size firms, with six representing companies with annual revenues below $500 million, two between $500 million and $1 billion, fourteen between $1 billion and $10 billion, and six exceeding $10 billion. The sample also reflects organizations with substantial operational maturity, as none of the participants were employed in firms younger than ten years, and most represented companies with more than twenty-five years of operating history. This organizational context suggests that participant responses are informed by established corporate structures and formalized strategic approaches to innovation and startup engagement.

Table 1. Demographics of the survey participants.

		Count
Experience (years)	Less than 5	2
	6-15	12
	16-20	3
	20+	11
Educational Background	Construction Engineering and Management	13
	Architecture	5
	Engineering	4
	Business	2
	Information Systems	1
	Other	3
Current Role in the Company	Senior Management	9
	VDC Manager	6
	Innovation and/or Technology Manager	5
	Project Manager	1
	Superintendent	1
	IT Manager	1
	Other	5

Engagement Modes

First, respondents were asked to specify the particular engagement types their organizations had pursued. Given that corporations can interact with startups through multiple channels simultaneously, participants were instructed to select all applicable engagement forms they had experienced. The findings reveal that nearly all firms engaging with startups as corporate customers through purchasing or leasing products (26 respondents, 93%). Pre-market piloting was the second most prevalent engagement approach, with 21 respondents (75%), followed by providing ideas or locations (12 respondents, 43%), direct capital investment (9 respondents, 33%), and facilitating connections to other customers (8 respondents, 29%).

Additionally, the survey participants are asked to select the engaged startups from a list of 30 startups, all of which are listed as top startups in 2024. The results showed that 79% of the respondents had engaged with Drone Deploy, followed by OpenSpace (39%) and Join (39%). It is important to note that at the time of data collection, DroneDeploy was operating in a Series E funding stage, and its inclusion reflects its classification as a venture-backed startup in an active growth phase rather than a newly founded firm. To visualize the relationship between collaboration modes and the most engaged startups, we analyzed the co-occurrence between pairs using a Sankey diagram. Figure 1 illustrates the Sankey diagram, which shows the relationship between engagement types, invested startups, and startup identification channels.

The clustering of thick lines around certain startups reveals their higher exposure and acceptance in the industry. As the thickness of the lines indicates, “Purchasing products/licenses/services” is the most frequently selected engagement type, demonstrated by the thickest line connecting it to Drone Deploy. Compared to other partnership types connected to Drone Deploy (pre-market testing/piloting, and funding), most companies purchased Drone Deploy services. This might stem from the maturity and observable benefits of the technology that Drone Deploy uses. Reality capture has been utilized in various industries for years and has gained popularity in the construction sector in recent years. Reality capture offers numerous benefits to contractors and is gaining increasing importance for project delivery (Fobiri et al., 2022). Two software followed Drone deploy: Join and Openspace. Join is an early-stage collaborative project management platform, and OpenSpace is an AI-driven photo documentation platform that also contributes to contractors’ smart project delivery.

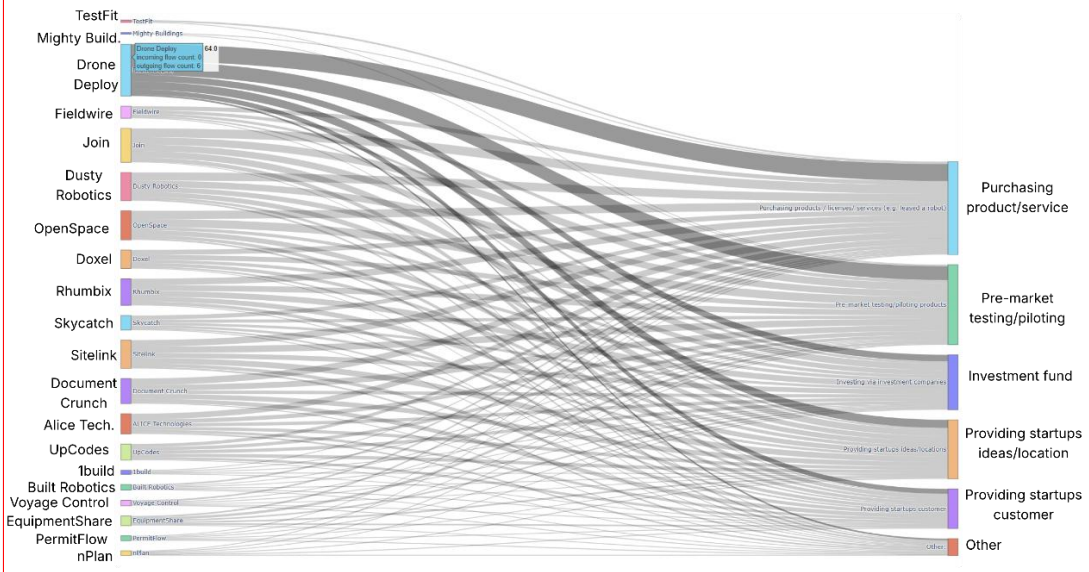

Figure 1. Sankey Diagram

Barriers to Engage with Technology Startups

The participants were given a list of barriers and asked to select the top three barriers that affected their engagement, based on their experience through their partnership. Figure 2 presents the barriers to engagement and strategic collaboration with startups, grouped into four thematic categories

(Organizational/Resource, Knowledge & Fit, Strategic/Cultural, and Risk/Legal). The stacked bars illustrate the relative weight of individual sub-barriers within each theme, with counts shown on the bars. This representation highlights that knowledge- and fit-related issues (e.g., identifying suitable startups, lack of sector knowledge) and organizational/resource constraints (e.g., limited support, time pressures) emerged as the most significant challenges compared to cultural or risk-related concerns. Within the Organizational and Resource theme, limited resources and support refers to financial constraints, such as limited budgets for pilot initiatives, and human resource constraints, including a lack of dedicated personnel or executive support, while more urgent activities elsewhere and time spent reflect competing operational priorities and coordination burdens. Internal communications captures challenges related to cross-departmental information flow and alignment. The Knowledge and Fit theme includes difficulties in identifying suitable startups, startups' limited understanding of construction-specific processes, industry fragmentation, and technical or procedural integration challenges. Strategic and Cultural barriers reflect misalignment in objectives, organizational mindsets, and long-term innovation strategies between firms and startups. Finally, Risk and Legal barriers encompass concerns related to technological uncertainty, return on investment, and intellectual property protection.

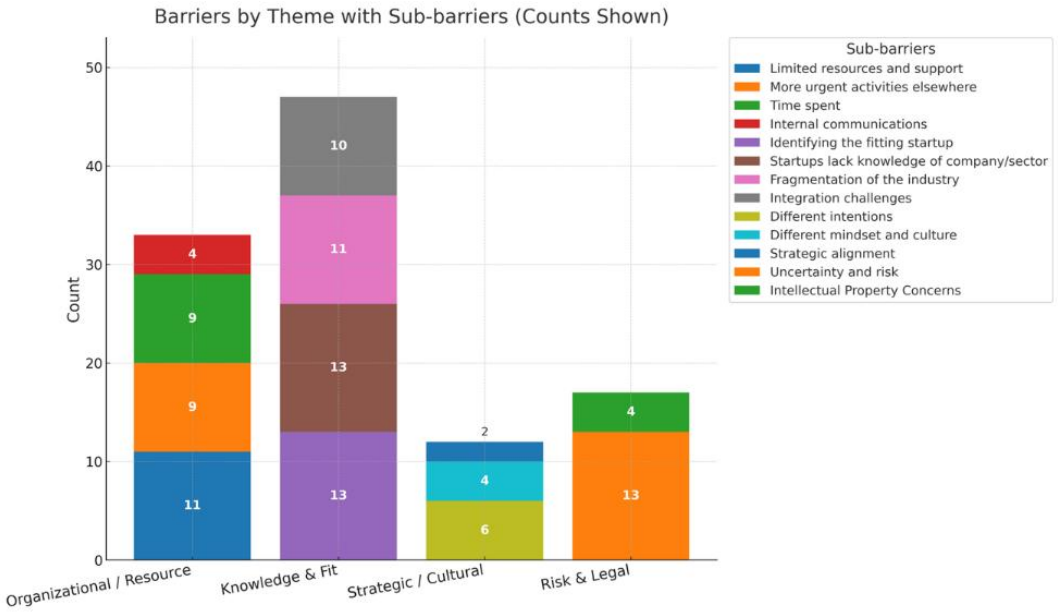

Figure 2. Barriers to startup engagement with sub-barriers.

The results reveal that barriers to engagement and strategic partnerships with startups cluster into four overarching themes: knowledge & fit, organizational/resource constraints, strategic/cultural misalignment, and risk/legal concerns. Among these, knowledge and fit-related issues stood out as the most critical challenges. Firms emphasized difficulty in identifying suitable startups and highlighted the limited sector-specific knowledge among startups themselves. This reinforces earlier findings that mismatches in expertise and capability are common impediments to corporate startup collaboration, particularly in fragmented industries like construction (Prashantham, 2021). Similarly, Banka et al. (2024) evaluated corporate concerns in such collaboration and found that finding matching startups

and startups lacking knowledge of corporate sectoral activities, based on the majority of the transport sector. Such gaps hinder not only the selection process but also the scalability of pilot projects, thereby reducing the likelihood of transitioning to long-term partnerships. On the other hand, even though studies like Banka et al. (2024) and Wójcik (2020) revealed that concerns about intellectual property rights are frequently mentioned by corporations, in our study, it was found as the one of the least frequent concerns compared to others. This difference might stem from the nature of the research samples. One important difference that needs to be highlighted is that our studies only focus on mid-to large-sized construction companies in the U.S, while Banka et al. (2024) evaluated international corporations in transport, technology, and other digital services sectors. Accordingly, compared to such services, the construction sector is leveraging innovative technology rather than seeking to own creative ideas. In sectors dealing heavily with digital technologies, intellectual property is a core asset. In contrast, if construction corporations are primarily looking for implemented solutions to improve efficiency, the ownership risk of the underlying creative property may be less immediate than operational or financial risks (e.g., the risk of losing funds due to the high failure rate of startup projects, which scored significantly higher in the source study).

Strategic and cultural misalignment, including differences in intentions, mindsets, and organizational culture, appeared less frequently but is nonetheless significant. These barriers highlight the challenge of reconciling entrepreneurial agility with established corporate structures. Prior studies suggest that building trust and aligning long-term strategic visions are critical for overcoming such divides (Weiblen & Chesbrough, 2015). Taken together, these results point toward two key implications. First, improving mutual understanding and fit through better communication, sector-specific knowledge sharing, and transparent selection processes may provide the greatest leverage for fostering meaningful engagement. Second, developing organizational readiness in terms of dedicated resources, leadership support, and integration capacity is critical for translating pilot projects into strategic partnerships. Without progress on these two fronts, risk mitigation and cultural alignment efforts are unlikely to gain traction.

On the other hand, risk and legal concerns, while less frequently emphasized, remain underlying factors that shape decision-making in engagement strategies. Companies tend to perceive these risks not merely as legal liabilities but as reflections of broader uncertainty about the startup ecosystem's stability and return potential. This perception reinforces the finding that construction firms' innovation strategies remain largely cautious and operationally driven, prioritizing short-term performance over exploratory collaboration. Overall, the results underscore that successful corporate–startup engagement in construction depends less on eliminating all risks and more on creating structured mechanisms for learning and adaptation. By institutionalizing transparent evaluation frameworks, cross-sector knowledge transfer, and iterative pilot processes, firms can gradually transition from transactional collaborations to sustained innovation partnerships that strike a balance between agility and strategic control.

Conclusion

Technology startups are inherently innovative, and construction companies are increasingly engaging with them in response to the growing demand for digitalization and technological advancement within the industry (Yücel & Comu, 2025) . These collaborations represent a vital mechanism for accelerating innovation diffusion, enhancing productivity, and addressing long-standing inefficiencies in project delivery. By evaluating the collaboration experience of construction companies with startups, this study reveals that the nature and depth of these engagements vary considerably. While mature technologies such as reality capture and AI-driven project documentation tools are rapidly

adopted through straightforward, transactional relationships, more transformative and strategic partnerships remain limited.

Persistent barriers related to knowledge gaps, organizational readiness, and cultural alignment continue to restrict collaboration depth. Many firms struggle to identify suitable startups, allocate dedicated resources, and bridge differences in operational pace, priorities, and mindset. These challenges highlight the need for systematic approaches to partnership building that go beyond isolated pilot projects. Intentional investment in organizational learning, sector-specific knowledge exchange, and internal innovation capabilities can help construction firms better navigate the startup ecosystem. Ultimately, overcoming these challenges will require cultivating mutual trust and long-term commitment between startups and established firms. By fostering open communication channels, transparent evaluation frameworks, and co-learning mechanisms, construction companies can evolve from cautious adopters of proven technologies to proactive partners shaping the future of industry innovation. Such evolution not only enhances their competitive advantage but also contributes to the broader digital transformation and resilience of the construction sector.

This study contributes to the growing body of knowledge on corporate–startup collaboration by identifying engagement patterns across technology and the persistence of barriers that limit deeper strategic partnerships. By categorizing these barriers into four thematic clusters and linking them to industry characteristics, the study offers a nuanced understanding of why construction firms often remain cautious adopters rather than co-innovators. However, several limitations are also acknowledged, such as the sample size and cross-sectional nature of the data, which restrict the ability to observe evolving partnership dynamics over time. Furthermore, self-reported responses may introduce perceptual biases in assessing engagement experiences and barriers. The authors' ongoing research aims to address these limitations through mixed-method approaches, including machine learning and thematic analysis that integrate network or performance data to validate and extend the findings.

References

Antonellis, D. (2023). *Suffolk Technologies BOOST 4 Cohort Selected to Address Industry Challenges*. Business Wire. https://www.businesswire.com/news/home/20230918772313/en/Suffolk-Technologies-BOOST-4-Cohort-Selected-to-Address-Industry-Challenges

Arabshahi, M., Wang, D., Sun, J., Rahnamayiezekavat, P., Tang, W., Wang, Y., & Wang, X. (2021). Review on Sensing Technology Adoption in the Construction Industry. *Sensors*, *21*(24), Article 24. https://doi.org/10.3390/s21248307

Banka, M., Chmiel, N., Kostrzewski, M., Marczewska, M., Kowalski, A. M., Sedkiewicz, K., & Salwin, M. (2024). Understanding corporate concerns. Barriers and challenges in corporate–start-up collaboration. *Journal of Open Innovation: Technology, Market, and Complexity*, *10*(4), 100388. https://doi.org/10.1016/j.joitmc.2024.100388

Bańka, M., Marczewska, M., Andrade, R. D. D., Kowalski, A., Boulangé, P., Sedkiewicz, K., & Murawski, J. (2025). Collaboration between corporations and startups: Goals, expectations and outcomes. *Journal of Small Business and Enterprise Development*. https://doi.org/10.1108/JSBED-04-2024-0219

Bertin, C., & Mavoori, H. (2024). Innovative Technology-Based Startup–Large Firm Collaborations: Influence of Human and Social Capital on Engagement and Success. *IEEE Transactions on Engineering Management*, *71*, 11923–11935. https://doi.org/10.1109/TEM.2022.3187924

Elkhayat, Y., Adel, K., & Marzouk, M. (2024). Technology adoption in the construction industry (1999–2023): Science mapping and visualization. *Automation in Construction*, *165*, 105491. https://doi.org/10.1016/j.autcon.2024.105491

Fobiri, G., Musonda, I., & Muleya, F. (2022). Reality Capture in Construction Project Management: A Review of Opportunities and Challenges. *Buildings*, *12*(9), Article 9. https://doi.org/10.3390/buildings12091381

Hottenrott, H., & Lopes-Bento, C. (2016). R&D Partnerships and Innovation Performance: Can There Be too Much of a Good Thing? *Journal of Product Innovation Management*, *33*(6), 773–794. https://doi.org/10.1111/jpim.12311

Kalinowska-Beszczyńska, O., & Prędkiewicz, K. (2024). MedTech start-ups: A comprehensive scoping review of current research trends and future directions. *PLOS ONE*, *19*(8), e0307959. https://doi.org/10.1371/journal.pone.0307959

Khan, A. N., Mehmood, K., & Soomro, M. A. (2024). Knowledge Management-Based Artificial Intelligence (AI) Adoption in Construction SMEs: The Moderating Role of Knowledge Integration. *IEEE Transactions on Engineering Management*, *71*, 10874–10884. https://doi.org/10.1109/TEM.2024.3403981

Laboe, D. (2023). State of The Built World: Corporate Venture Funds Take The Reigns. *BuiltWorlds*. https://builtworlds.com/news/state-of-the-built-world/

Liu, J., Low ,S. P., & and Zhang, Q. (2018). Enterprise risk management practices of top ENR international contractors. *International Journal of Construction Management*, *18*(5), 364–374. https://doi.org/10.1080/15623599.2017.1326299

Nduro, E., & Duodu, B. (2025). Inbound open innovation in construction firms: Intellectual capital antecedents and performance consequences. *Engineering, Construction and Architectural Management*, *ahead-of-print*(ahead-of-print). https://doi.org/10.1108/ECAM-09-2024-1262

Nissen, H. A., Evald, M. R., & Clarke, A. H. (2014). Knowledge sharing in heterogeneous teams through collaboration and cooperation: Exemplified through Public–Private-Innovation partnerships. *Industrial Marketing Management*, *43*(3), 473–482. https://doi.org/10.1016/j.indmarman.2013.12.015

Prashantham, S. (2021). Partnering with Startups Globally: Distinct Strategies for Different Locations. *California Management Review*, *63*(4), 123–145. https://doi.org/10.1177/00081256211022743

Regona, M., Yigitcanlar, T., Xia, B., & Li, R. Y. M. (2022). Opportunities and Adoption Challenges of AI in the Construction Industry: A PRISMA Review. *Journal of Open Innovation: Technology, Market, and Complexity*, *8*(1), Article 1. https://doi.org/10.3390/joitmc8010045

Santa-Maria, T., Dougnac, N., Llorente-González, L. J., & Geissdoerfer, M. (2025). From Challenges to Impact: Drivers, Barriers, and Shared Resources in Sustainability-Oriented Corporate-Startup Alliances. *Business Strategy and the Environment*. https://doi.org/10.1002/bse.4341

Turetta, A. L., & Junior, S. L. (2023). CORPORATE VENTURE CAPITAL FOR ESTABLISHING LINKS BETWEEN LARGE AND TRADITIONAL INDUSTRIAL COMPANIES AND STARTUP FIRMS: A REGIONAL INNOVATION SYSTEM SURVEY. *Brazilian Journal of Management and Innovation (Revista Brasileira de Gestão e Inovação)*, *10*(2), 92–107. https://doi.org/10.18226/23190639.v10n2.06

Waddock, S. A., & Graves, S. B. (1997). The Corporate Social Performance–Financial Performance Link. *Strategic Management Journal*, *18*(4), 303–319. https://doi.org/10.1002/(SICI)1097-0266(199704)18:4<303::AID-SMJ869>3.0.CO;2-G

Wagner, S. M. (2021). Startups in the supply chain ecosystem: An organizing framework and research opportunities. *International Journal of Physical Distribution & Logistics Management*, *51*(10), 1130–1157. https://doi.org/10.1108/IJPDLM-02-2021-0055

Wang, C., & Hu, Q. (2020). Knowledge sharing in supply chain networks: Effects of collaborative innovation activities and capability on innovation performance. *Technovation*, *94–95*, 102010. https://doi.org/10.1016/j.technovation.2017.12.002

Weiblen, T., & Chesbrough, H. W. (2015). Engaging with Startups to Enhance Corporate Innovation. *California Management Review*, *57*(2), 66–90. https://doi.org/10.1525/cmr.2015.57.2.66

Wójcik, P., Obłój, K., Wąsowska, A., & Wierciński, S. (2020). Corporate acceleration process: A systems psychodynamics perspective. *Journal of Organizational Change Management*, *33*(6), 1163–1180. https://doi.org/10.1108/JOCM-05-2019-0136
Yücel, B., & Comu, S. (2025). Evaluating Factors Affecting Construction Technology Start-Up Investments and Investor Behavior. *Journal of Construction Engineering and Management*, *151*(11), 04025177. https://doi.org/10.1061/JCEMD4.COENG-16333
Zahoor, N., & Al-Tabbaa, O. (2020). Inter-organizational collaboration and SMEs' innovation: A systematic review and future research directions. *Scandinavian Journal of Management*, *36*(2), 101109. https://doi.org/10.1016/j.scaman.2020.101109
Zhang, L., & Chen, W. (2021). How Do Innovation Network Structures Affect Knowledge Sharing? A Simulation Analysis of Complex Networks. *Complexity*, *2021*(1), 5107630. https://doi.org/10.1155/2021/5107630