EXTENDED ABSTRACT

Impact of Venture Capital on Entrepreneurship for Robotics in Construction

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1. Introduction

Technology-based ventures, also known as Start-Ups, have a reputation for experiencing both phenomenal successes and catastrophic failures. In recent times, the construction industry has witnessed the emergence of novel service-oriented technology firms, particularly in the software domain, that have successfully exited their initial market via merger or acquisition (M&A), initial public offering (IPO) or a managed buyout (MBO). Conversely, the first vertically integrated manufacturing technology "unicorn," valued at over 1 billion USD, was established; however, it has since become defunct, highlighting the daunting obstacles associated with establishing, expanding, and maintaining a hardware technology enterprise in the architecture, engineering, and construction (AEC) sector.

2. Research Problem Statement

The construction industry is a complex product system (CoPS) (Bertelsen 2003) that accounts for 13% of the global gross domestic product (GDP). It is notorious for experiencing project delays, cost overruns, and operates on thin profit margins (Akintoye and Skitmore 1991; Hillebrandt 2000). Prior research in the AEC domain has identified the long-standing, project-based, and asset-heavy industry symptomatic of low-risk appetite for innovation due to inadequate resources (Nam and Tatum 1989). Additionally, the AEC industry faces challenges in reconciling trade specialization, professional standards, and industry norms (Hall, Algiers and Levitt 2019). Consequently, systemic innovation in the AEC sector has been slow (Taylor and Levitt 2005), and only recently have emerging AEC companies embraced novel production paradigms such as Lean, Design for Manufacture and Assembly (DfMA), and Digital Fabrication (dfab) (Ng and Hall 2019). Some of these innovations take place in Start-Ups promising to transform the construction industry by integrating data from design to production, making it more productive (García de Soto et al. 2018), and sustainable (Agustí-Juan et al. 2017). However, hardware technologies in AEC face unique challenges compared to software technologies since they deliver physical, complex, customized products with high demand fluctuations, long product development cycles (Gann 1996), and typically low batch sizes. To scale early, these startups often seek external funding, such as professionally managed venture capital, to meet their significant financial requirements. Venture capital funding is a high-risk private equity investment that focuses on emerging, high-growth startups, offering equity or a stake in the company's ownership.
To date, minimal scholarship has explored the effects and implications of venture capital on hardware startups in AEC, and vice versa. As such, this research aims to investigate the impacts of venture capital on new hardware technology ventures in construction.

3. Research methodology and approach

To address the research proposition, this study analyzes influential factors and relationships from the perspectives of both new firms and venture capitalists. The study aims to enhance understanding of the mechanisms involved in identifying and pursuing business opportunities by aligning them with appropriate internal resources such as financial, physical, and human capital. It also seeks to comprehend investment evaluation, fund structure, and strategic portfolio management from the viewpoint of venture capitalists. These interdependent factors necessitate meticulous examination through empirical data, which is directly collected from professionals of emerging technology ventures and respective investors in AEC.

The empirical data set comprises semi-structured and open-ended interviews (N=90) conducted in 2022 and 2023. The research incorporates stakeholder groups such as (Co)-Founders, investors (Business angels, venture capital, private equity, and mutual funds), clients or partners, such as incumbent companies in AEC, and other third parties, including consultancies, innovation programs, and research institutions. The interviews were conducted in person in Switzerland and the United States, as well as in 15 other countries using a video call format. The transcribed interviews, spanning more than 100 hours, are analyzed using computer-assisted qualitative data analysis software (CAQDAS) MAXQDA 2022: First, the interview transcripts are inductively paraphrased, or coded. Secondly, themes and categories are established to convey a deeper understanding of the research data. Further on, this research utilizes the abductive research methodology of systematic combining, which involves simultaneous evolution of theoretical framework, empirical fieldwork, and case analysis (Dubois and Gadde, 2002a). Initially, systematic combining aligns theory and reality, followed by continuous direction and redirection of theory and reality based on the evolving case, available theories, analytical framework, and empirical data.

3. (Expected) Key Findings

Preliminary analysis of the interview transcripts reveals that hardware technology ventures in the Architecture, Engineering, and Construction (AEC) sector face higher capital expenditures and lower investment returns compared to software technology ventures in the same sector. Additionally, participants in the study cohort view Real Estate (RE) and property technology (PropTech) as distinct from construction technology (ConTech). However, investors in ClimateTech with expertise in hardware investments have shown interest in ConTech, given its importance to infrastructure, energy, and transportation sectors. Moreover, some participants have expressed concerns and others have shown interest in incoming talent and technology from industries such as information technology (IT) and manufacturing.The construction industry in general is experiencing tension due to increasing interest rates and a slowing economy, while there is a considerable amount of venture capital looking for deployment. In this context, macroeconomic conditions are stimulating venture capital funds to invest in ventures at higher risk levels, as expected returns remain constant. However, some later-stage hardware technology ventures in AEC have reported reductions in headcount due to financing bottlenecks, which could lead to down rounds in the future. Such down rounds pose challenges to ventures in terms of valuation and equity dilution, but present opportunities for investors.

Furthermore, hardware technology ventures in AEC have emphasized the importance of early and frequent access to pilot projects, while university Start-Ups and academic Spin-Offs have reported experiencing frictions related to intellectual property that hinder technology and knowledge transfer to the incumbent construction industry. Notably, differences in data samples from Switzerland and the United States, specifically in the Silicon Valley ecosystem, have emerged. Further analysis using abductive inferences will identify additional themes of convergence and divergence in the data, with the aim of systematically easing frictions between stakeholder expectations, perceptions, and actions. Eventually, we expect our findings to help align stakeholder incentives and increase collaboration with hardware technology ventures in AEC.

4. Predicted Implications and Outlook

Loose couplings among permanent business networks in the construction industry pose significant challenges to innovation (Dubois and Gadde 2002b). However, if parties agree to cooperate across projects, it can lead to a controllable inter-organizational collaboration in AEC (Kornelius and Wamelink 1998). The presented study aims to provide empirical evidence collected from expert stakeholders in the field of hardware technology in construction towards building integrated models of project and product delivery. The data also suggests that industry-specific innovation clusters, such as business incubators and colocated accelerators that also serve as an investment vehicle, offer promising opportunities for development (Cohen 2013).

Future research should focus on assessing venture stages, contextual settings, including legal regulations, trade union agreements, industry rivalry (Porter 1979), and their impact on the dynamic capabilities of firms (Teece, Pisano and Shuen 1997). This comprehensive understanding of proposed factors should help hardware technology ventures in AEC to develop business models that aim to strengthen existing strategic, tactical, and operational couplings beyond the scope of single construction projects (Gann 1996).

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