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Bug or feature? Institutional misalignments between construction technology and venture capital

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ABSTRACT

Despite substantial investments into new technologies, the adoption of systemic innovations such as construction robotics remains limited. Therefore, this study investigates the discrepancy between the assumed advantages of construction technologies and their actual performance during practical implementation, using construction robotics as the empirical case. Through an abductive thematic analysis of 127 interviews across Europe and North America, we identify six enablers of institutional misalignment: cognitive frame differences, divergent time horizons, conflicting market strategies, product versus revenue focus, varying risk tolerances, and information asymmetry. These misalignments between startup founders' technological logic and investors' economic logic constrain adoption, emphasizing the influence of institutional dynamics over technological feasibility. Our findings suggest these challenges are not unique to construction robotics but may extend to other emerging construction technologies. This highlights the critical need for aligning institutional logics to fully harness the potential of innovation in construction.

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Institutional logic; entrepreneurship; AEC; construction robotics; new practice

> The game is about how to survive technology cycles and economy cycles. You want to perform well on the intersections. - Investor.

Introduction

The recent surge in innovation funding from venture capital firms highlights a growing interest in the construction industry's potential for disruptive change. While this influx of capital offers significant opportunities, it also presents notable challenges. A key concern is the risk of amplifying the "hype cycle" surrounding new technologies. For example, Lideloew *et al.* (2023) illustrate using the case of Building Information Modeling (BIM) how heightened initial enthusiasm can lead to unrealistic expectations. When these expectations are unmet, it can hinder the long-term adoption of the technology. Therefore, the critical challenge is ensuring that the momentum generated by innovation funding supports sustainable and meaningful technology integration.

The theory of institutional misalignment can explain this tension. Institutional misalignment occurs when established industry norms, practices, or structures clash with emerging developments. Such misalignments can amplify conflicts and impede the diffusion of innovation (Polzin *et al.* 2018). Although institutions typically provide the stability necessary for industry evolution, they can also resist essential change. At the same time, misalignments do not always result in adverse outcomes; under certain conditions, they can lead to constructive realignments as industries are forced to adapt (Scott 2013). Indeed, Corsaro and Snehota (2011) and Korber *et al.* (2022) argue that these tensions can sometimes ignite creativity, prompting industries to reconfigure in ways that ultimately prove productive.

Despite these insights, the root causes of institutional misalignments in the context of construction innovation remain poorly understood. Addressing or mitigating the tensions they create is challenging without a deeper understanding of these factors. Moreover, the dual role of institutional misalignments as both a barrier and a catalyst for innovation is not well-defined, especially in mature and well-established sectors such as construction. Understanding whether

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these misalignments hinder progress or foster creativity is crucial for effectively leveraging innovation in such mature and entrenched industries.

The emerging interest in construction robotics offers an opportunity to further study these dynamics. The recent influx of venture capital has accelerated advancements in construction robotics, but these investments can emphasize short-term, marketable gains over sustainable innovation. Funding mechanisms that come with the institutional motivations and interests of venture capital can risk overshadowing the development of resilient technologies that address more profound industry challenges. However, these financial pressures can also drive the industry to reassess entrenched practices and priorities, potentially leading to more innovative and effective solutions.

Therefore, this paper seeks to explore how institutional misalignments between funders and innovators impact technological development, specifically focusing on the case of construction robotics. Several construction robotics startups have emerged in recent years, offering specialized technological solutions on and off construction sites. These startups are often supported by venture capital, which helps offset the initial costs of technological integration. However, implementing construction robotics requires significant changes in operational and strategic practices, revealing inherent tensions between technological potential and economic realities (Kangari and Halpin 1990, Katila *et al.* 2018, Sawhney *et al.* 2020). These challenges and opportunities provide a rich empirical context for examining the institutional conditions that affect technology adoption in construction.

The paper is structured as follows: First, we examine the context and background, including ongoing investments in construction technologies, to develop our research rationale. Next, we elaborate on our theoretical framework, focusing on institutional misalignment within organizational fields. We then outline our primary research question on potential misalignments between venture capital and construction robotics companies. Our methodology section describes the abductive theme analysis employed, followed by our findings, which identify eleven dimensions of misalignment between founders and venture capitalists. The paper concludes by discussing whether these misalignments should be seen as features or bugs[1] and exploring the broader implications of our research findings.

Context and background

Construction technology investments

In recent years, investors have shown increasing interest in technology startups within the construction industry, leading to a global investment volume of 5.38 billion USD in 2022, with growing investments and average deal sizes (CEMEX Ventures 2023). Venture capital has targeted software startups specializing in artificial intelligence, project scheduling, and data capture (Maulana 2023). Despite this interest, the percentage of investments in construction technology remains low, averaging only 0.08% of total industry spending from 2017 to 2021 (U.S. Census Bureau 2023). Although this investment has a slight upward trend, as indicated by the time series' trend line in Figure 1, the coefficient of determination (R^2) is 0.179, suggesting a modest level of predictive accuracy. In comparison, in 2023, the sustainability sector experienced an investment percentage of 8.4% relative to its total industry spending in the U.S., while the mobility sector saw an investment percentage of 4.9% despite

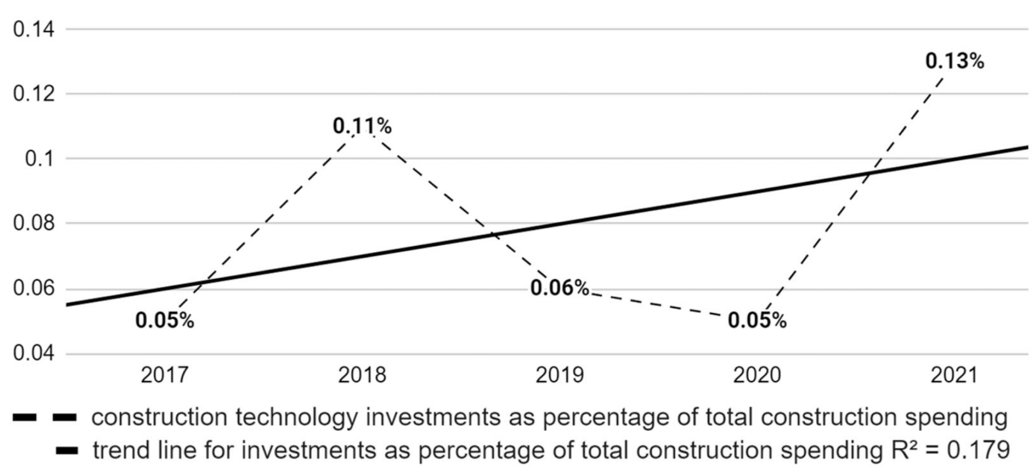

Figure 1. U.S. construction technology investments relative to industry spending 2017-2021, based on Mostamandy and Ledbetter (2022) and U.S. Census Bureau (2023).

significantly lower investment volumes in 2022 and 2023 (Teare 2023, BEA, 2024).

The construction robotics paradox

Construction robotics can transform long-standing industry practices by automating labor-intensive tasks while improving precision and quality (Bock 2015). Adopting robotic technologies in construction can enhance worker safety (You *et al.* 2018), reduce environmental impact (Agusti-Juan and Habert 2017), and lead to more cost-effective workflows (Brosque and Fischer 2022). Moreover, recent advancements in construction robotics have significantly expanded the capabilities and applications of these technologies in both academic research and industry practice (e.g. Ma *et al.* 2020, Graser *et al.* 2021, Linner 2023).

Consequently, the construction robotics sector saw substantial investments by VC: ICON received USD 450m, Built Robotics 112m, Dusty Robotics 69m, Diamond Age 58m, Monumental 25m, and RoboCon 20m (Crunchbase 2024). Investors predict a continued rise in venture capital for this sector (Zacua Ventures n.d.), further highlighting its potential for efficiency, safety, and cost-saving advancements in construction.

However, only 5% of the total construction technology investment volume 2022 was allocated to construction robotics (CEMEX Ventures 2023). Therefore, in an optimistic calculation assuming an average allocation of 0.08% towards construction technology investments as a percentage of total U.S. construction industry spending (Figure 1), with a 5% sub-allocation to construction robotics, only an equivalent of 0.004% of U.S. construction industry spending is invested in construction robotics today. In other words, per every 25,000 USD spent in construction activities in the U.S., only 1 USD is invested into construction robotics[2]. This low estimate seems paradoxical considering the industry's predicted labor shortages (Agapiou *et al.* 1995, Dainty *et al.* 2005, Connaughton 2012), which should drive demand for automation and technological solutions (Bock 2015). As such, construction robotics' current low adoption, implementation, and diffusion rates underscore a disconnect between theoretical benefits, innovation funding, and practical application in the industry (Bosch-Sijtsema *et al.* 2021).

Kangari and Halpin (1990) highlighted the need to align societal needs and economic viability with technological considerations in construction robotics. Since then, research has advanced the understanding of socio-technical variables that enable and impede robotization in construction environments (Walzer *et al.* 2022, Graser *et al.* 2023, Wu *et al.* 2024), but less focus has been placed on the socio-economic domain (Bademosi and Issa 2021). Economic, organizational, personnel, technological, policy, and regulatory barriers hinder the integration of these innovations in the construction industry (Tan *et al.* forthcoming). Comprehensive understanding and mitigation of these barriers are essential to unlock the development potential of systemic innovation in this sector.

Research rationale

Innovation adoption (Tatum 1987, Manley and McFallan 2006), implementation (Slaughter 1998, Manley *et al.* 2009), and diffusion (Taylor and Levitt 2004, Manley 2008) have been studied in construction management. Recent studies emphasize engaging stakeholders to enhance the adoption of automation technology (Atkin and Skitmore 2008, Chen *et al.* 2018). Agusti-Juan and Habert (2017) noted that construction robotics introduces new work design possibilities for handling standardized and non-standardized products within construction projects, signifying a significant shift with implications for job roles, skills requirements, and project workflows. Therefore, exploring construction robotics beyond its technological aspects is essential for anticipating and managing its impact on construction management practices. Yet, more evidence is needed on the institutional processes facilitating these developments (Scott 2013). Given the critical role of institutions in management research (Aldrich and Fiol 1994, Bylund and McCaffrey 2017), misaligned institutional logic in the investor-investee relationship can significantly impact the practical application of innovative technologies in construction. For instance, other industries show that funding partners' institutional logic can significantly influence firm and sector innovation (Pahnke *et al.* 2015).

In this regard, using institutional logic as an analytical framework can help understand the gap between the theoretical benefits and the actual use of construction robotics, highlighting how varying stakeholder logic can hinder technology adoption. Inspired by Orlikowski's (2010) "studying practice" approach, this study explores how loose couplings in the construction industry impede coordination and knowledge sharing, thus hindering innovation and productivity (Dubois and Gadde 2002a). This approach addresses technical, market, cultural, and institutional aspects critical for understanding innovation adoption in construction management research.

Theoretical point of departure

This research builds upon the observation that misalignments exist between the innovative capabilities of new technologies and the institutional readiness to adopt them within the economic context of the construction industry (Bosch-Sijtsema *et al.* 2021). While technological advancements promise significant improvements, the primary obstacles to leveraging technological innovation may lie not within the technologies themselves but within the broader organizational and socio-economic contexts (Jacobsson and Linderoth 2010, Jacobsson *et al.* 2017).

Given the multiplicity of stakeholders, the construction industry faces diverse institutional pressures (Levitt 2011). These misalignments provide a fertile ground for exploring mechanisms that impede the adoption, implementation, diffusion, and effective utilization of technological advancements in construction. New firms encounter significant challenges in overcoming entrenched industry practices (Hall *et al.* 2020). Research highlights the importance of addressing technological, market, and organizational changes (Tidd *et al.* 2005) and cultural dimensions (Seymour and Rooke 1995, Chan and Raeisaenen 2009). This perspective supports calls for deeper integration of social science methodologies into construction management research (Koch *et al.* 2019, Volker 2019).

Organizational fields and institutions

Organizational fields are critical in understanding the structure and dynamics of industries and markets (DiMaggio and Powell 1983). This perspective, as articulated in institutional theory (DiMaggio 1991), refers to those organizations that, in the aggregate, constitute a recognized area of institutional life. Organizational fields are not collections of firms or institutions that are similar or directly compete with each other (Scott 2013); they include the broader system of relationships and interactions among various actors, such as regulatory bodies, standards agencies, suppliers, customers, and financiers. These fields define the context within which organizations operate, innovate, and compete, shaping the "rules of the game".

North (1990) defines institutions as human constraints that structure political, economic, and social interactions. They guide individual and collective behavior through formal rules, informal norms, and enforcement characteristics (Burt 2004). As such, institutions profoundly impact economies' performance and the trajectory of societal development (North 1990, Hargadon and Douglas 2001).

By definition, institutions are relatively resistant to change (Jepperson 1991, Scott 2013). Consequently, institutional rigidity can stifle innovations, as these must overcome ingrained norms and systems to gain acceptance, further complicating the alignment of practices (Oliver 1991). Lastly, studying how institutions operate can reveal ways to make organizational fields more resilient and innovative (Ferguson 1998, Scott 2013).

Organizations and institutional logic

In the context of organizations, institutional logic can help outline the processes by which stakeholders assimilate and operationalize the norms and values inherent to their institutions. Institutional logic explains how belief systems and practices shape organizational and individual behaviors, revealing the significance of socially constructed historical patterns, assumptions, values, and rules within specific institutional contexts (Friedland and Alford 1991, Thornton *et al.* 2012). Institutional logic therefore examines how organizations and their stakeholders navigate and strategize within their institutional environments, influenced by broader cultural and societal narratives (DiMaggio and Powell 1983, Thornton and Ocasio 2008). Institutional logics, characterized by their fluctuating, co-existing, and potentially conflicting nature within a complex organizational landscape, provide a valuable lens for examining the dynamics of adaptation among organizations (Greenwood *et al.* 2011, Thornton *et al.* 2012).

Misaligned institutional logics

As institutional logics intersect, organizations find themselves in "logic blending" or "hybridity", where conflicting logics are negotiated to accommodate multiple institutional demands (Battilana and Dorado 2010). The concept of misaligned institutional logic suggests that institutional arrangements can create inconsistencies and tensions, transforming actors into change agents or institutional entrepreneurs capable of navigating these challenges (Seo and Creed 2002). With an improved understanding of the underlying mechanisms, insights can be gained into their causes, consequences, and potential resolutions (Sarasvathy

2001). Such inquiry aligns with the recommendations of Besharov and Smith (2014), who advocate for management research to explore institutional misalignments and their impacts across various organizational and sectoral contexts. Further, institutional logic helps move beyond the surface-level symptoms to consider broader cultural, social, and normative factors (Rasmussen *et al.* 2017, Lundberg *et al.* 2022).

Organizations have multiple strategic responses to these misalignments, such as compartmentalization, where different logics are applied in different organizational units or projects (Pache and Santos 2010), or hybridization, blending elements of competing logic to create a more cohesive and innovative approach (Battilana and Dorado 2010). As outlined by Pina e Cunha et al. (2005), misaligned institutional logic can lead both to positive and adverse outcomes and, eventually, these contradictions can catalyze organizational change and transformation in the construction sector(Gottlieb and Haugbølle 2013).

Institutional logics in construction

Studies on institutional logic in the built environment are limited but increasing. Thornton *et al.* (2005) examined how architecture firms balance aesthetic and efficiency logic. Gluch and Hellsvik (2023) explored the influence of multiple logics on construction stakeholders regarding sustainability. Linderoth (2017) highlighted that divergent institutional logic can hinder the adoption of Building Information Modeling (BIM) in construction. Harty and Leiringer (2017) emphasized the need to understand dominant institutional logic to resolve conflicts between the external environment and internal construction dynamics. Bylund and McCaffrey (2017) discussed how institutional uncertainty generally influences entrepreneurship, pointing to the complexity and uncertainty when institutional logics intersect.

Economic and technology logic

Entrepreneurship and management scholarship has increasingly focused on the dominant interplay between economic and technology logic (Shane 2000, Gompers and Lerner 2001, Hellmann and Puri 2002, Thornton and Ocasio 2008). These studies outline a complex landscape venture capitalists and entrepreneurs navigate based on these differing yet complementary logics.

Economic logic, emphasizing financial returns and risk management, contrasts with technology logic, prioritizing innovation and market disruption (Table 1). Walker and Weber (1984) and Kaplan and Stroemberg (2004) further explore the implications of these logics for organizational behavior and investment strategies, highlighting the critical role of transactional dynamics and evaluative frameworks in shaping industry trajectories.

Table 1 synthesizes the core findings from current scholarship, highlighting each logic's distinct characteristics, motivations, and outcomes. The table aims to clarify the general understanding of economic and technology logic in literature by presenting these elements.

Empirical setting: construction robotics

Despite the ideal types of institutional logic presented in Table 1, an empirical gap persists in examining

Table 1. Ideal types of institutional logics, based on Thornton *et al.* (2005).

Characteristics	Economic logic	Technology logic
Economic system	Venture capitalism, focuses on high-risk investments for substantial returns	Innovation-driven economy, emphasizing the development and commercialization of technologies
Sources of identity	Identified by investment vision, portfolio performance, and financial expertise	Defined by innovative contributions to technological expertise and industry leadership
Sources of legitimacy	Financial returns, successful exits, and portfolio growth	Technological breakthroughs, patents, and market adoption of technological solutions
Sources of authority	Investment decisions, financial analysis, and market insights	Technological vision, product development prowess, and industry knowledge
Basis of mission	To maximize investment returns and achieve financial growth through strategic funding	To advance technology and achieve market leadership through innovation and differentiation
Basis of attention	Market trends, investment opportunities, and financial forecasts	Technological advancements, R&D breakthroughs, and industry needs
Basis of strategy	Identifying and investing in high-potential startups, financial engineering, and exit planning	Developing cutting-edge technologies, securing intellectual property, and strategic market positioning
Logic of investment	Allocation of capital to ventures with high growth potential for financial returns	Investment in technology development, R&D, and scaling production capabilities
Governance mechanism	Board participation, financial oversight, and performance metrics	Agile development methodologies, technology roadmaps, and innovation management
Institutional entrepreneurs	Venture capitalists who shape the investment landscape and funding models	Entrepreneurs who pioneer new technologies and business models in the industry
Event sequencing	Key funding rounds, IPOs, and acquisition events that mark financial milestones	Technological milestones, product launches, and adoption by key markets or sectors
Structural overlap	Interactions with financial markets, regulatory bodies, and other sectors seeking technological solutions	Collaboration with research institutions, technology partners, and cross-industry applications

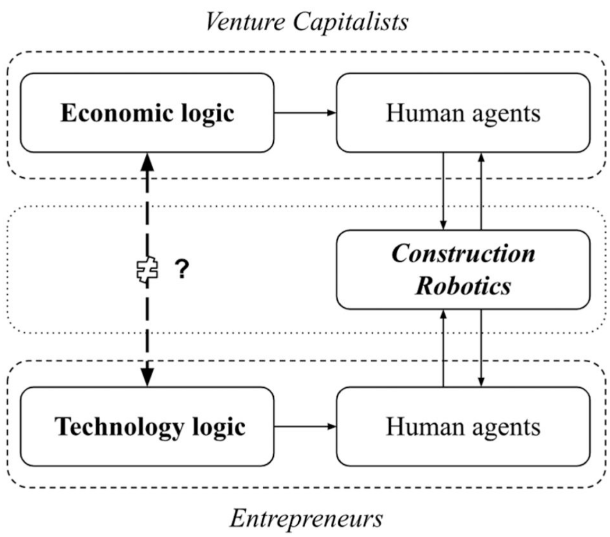

Figure 2. Scope of the study.

them in the context of construction robotics. A deeper understanding of these institutional logics is instrumental in recognizing how different actors within construction robotics prioritize certain practices over others, aiming to making innovation more “usable” for construction professionals (Dossick *et al.* 2019). As such, the principles of institutional logic are instrumentalized to establish the study’s analytical framework and conceptual understanding, providing a structured basis for exploring the dynamics at play within this empirical setting underexplored by construction management research.

Figure 2 presents a conceptual framework illustrating the dynamics between venture capitalists and entrepreneurs in construction robotics. It highlights potential misalignments between economic logic (venture capitalists) and technology logic (entrepreneurs). This framework shows how the systemic innovation both shapes and is shaped by human actions (see also Linderoth 2017). Integrating these perspectives addresses the unique challenges of aligning economic and technological goals in construction robotics, which is at the core of this study.

Summary of the research gap

Despite the increasing interest in construction robotics, research has yet to apply the institutional logic framework to analyze stakeholder perspectives in this domain. Current studies often overlook the discrepancies between the theoretical benefits and actual use of construction robotics, particularly the divergent institutional logic among venture capitalists and entrepreneurs. Addressing this gap can provide a deeper understanding of the barriers to effective technology adoption and integration in construction management.

Research question

The guiding research question, “What are possible institutional misalignments between construction robotics and venture capital?” aims to clarify some of the complexities of these institutional interactions.

Methodology

This study embraces a non-linear and interpretive approach anchored in abductive reasoning, drawing on the principles of systematic combining. This approach fosters a dynamic interplay between theoretical constructs and empirical observations (Dubois and Gadde 2002b). Characterized by its iterative and adaptive nature, this methodology permits the ongoing refinement of a theoretical framework, ensuring it evolves in response to emerging empirical insights (Kaplan and Orlikowski 2012, Timmermans and Tavory 2012). By situating the investigation closer to induction than deduction, systematic combining enables integrating empirical data with existing theory and the emerging context (Dubois and Gadde 2002b, Timmermans and Tavory 2012).

This fluidity in research design enables the iterative development and revision of preliminary hypotheses or “first suggestions” throughout the research process (Bamberger 2018). Abductive reasoning focuses on generating plausible explanations and uncovering discoveries by leveraging theories to challenge assumptions and employing data to describe phenomena, formulate tentative claims, and narrow down explanations. Through contrastive reasoning, abduction identifies patterns that reveal alternative dynamics and processes, offering a detailed understanding of complex subjects (Bamberger 2018).

Abductive thematic analysis

Employing a relatively novel method known as abductive thematic analysis, this study seeks to gain a richer understanding of participant perspectives while staying true to the essence of qualitative research (Thompson 2022). Thematic analysis is utilized to systematically break down and explain patterns in the empirical data, a crucial step in qualitative studies (Braun and Clarke 2006). Additionally, quotes from the data are employed to draw theoretical linkages abductively (Dubois and Gadde 2002b). Figure 3 summarizes the research method, further elaborated in the following sections, detailing the individual steps.

Participant selection

This study first utilized a purposive sampling approach, followed by a snowball sampling approach. Purposive sampling enables a better match between the participants and the aims and objectives of the research, thus improving the study's rigor and the trustworthiness of the results (Campbell *et al.* 2020). The first set of participants was chosen via the author's professional networks, scouting at in-person events, and proactively through communication channels such as e-mails. After each interview, participants were asked to recommend other possible candidates who could contribute to the study's aims. This approach creates momentum and captures an increasing chain of participation, also known as snowball sampling (Noy 2008).

The participant selection explicitly targeted two key groups to ensure the depth and relevance of the data: The first group (n = 39) comprises construction technology startup founders and executives. The aim is to capture firsthand experiences of navigating the startup ecosystem and the challenges faced during phases like scaling or seeking investment. The second group (n = 20) is composed of VC investors. The aim is to gain insights into the investment criteria and strategies VC prioritizes when evaluating construction technology startups that focus on robotics. Focusing on these distinct perspectives ensured a more comprehensive understanding of the dynamics between startups and their potential or actual financiers. Additionally, the study incorporates other stakeholders (n = 36) beyond the startup founders and investors, such as clients, partners, academics, advisors, etc. (Table 2).

Demographics

The empirical data set includes 127 semi-structured and open-ended interviews and conversations with 95

Table 2. Participant demographics (*N* = 95).

Participant role	No.	Focus area[a]	No.	Firm status	No.
(Co)-Founder	21	Robotics, Automation	28	Operational	91
Investor	20	Offsite, Prefabrication	23	of which in stealth	10
Executive	18	Software, Firmware	21	Defunct	2
Advisor	13	Financing, Equity	20	Exited	2
Other[b]	12	Internet of Things	15	*Geographical Region*	*No.*
Client	11	Climate, Energy	14	Continental Europe	39
Firm Type	*No.*	On-Site Construction	13	North America	31
Startup	32	Logistics, Supply Chain	12	Multinational	16
Other[c]	23	Additive Manufacturing	12	Asia-Pacific	7
Spinoff	20	Education, Academia	11	South America	2
Venture Capital	14	Real Estate, Property	10	*Study Population*	*No.*
Corporate VC	4	Artificial Intelligence	9	Interviews (n)	127
Private Equity	2	Facility Management	8	Interviewees (N)	95
if Venture, Stage	*No.*	Infrastructure, Civil	8	*Data Collection*	*No.*
Pre-Seed	25	Incubator, Accelerator	7	Total duration (h)	92
Seed	16	Wearables, Exoskeleton	5	Online (Verbatim)	59
Series A or B	9	Mixed Reality/AR/VR	4	In-person (Field Notes)	56
Acquisition or IPO	2	Policy, Legal	2	Online (Non-verbatim)	12

[a]Note that most firms are labeled with more than one focus area.
[b]These roles include consultants, academics, and government employees.
[c]This type includes multinationals, general contractors, and universities.

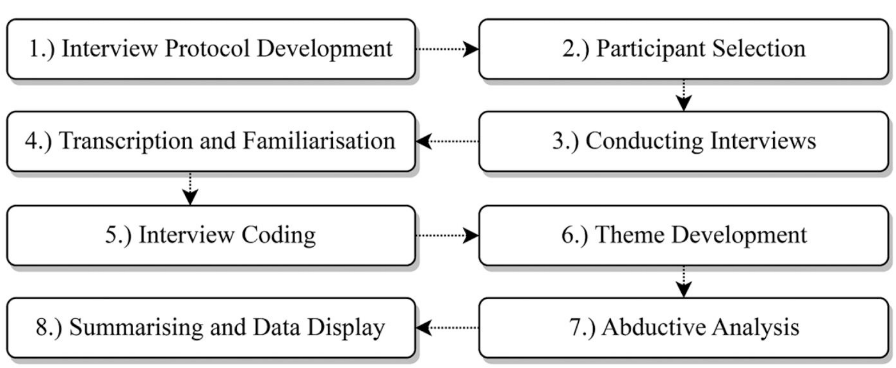

Figure 3. Flowchart of abductive thematic analysis, based on Thompson (2022).

industry informants conducted in 2022 and 2023. The interviews were conducted in person in Continental Europe (39), North America (31), as well as in Asia-Pacific (7) and South America (2), using a video call format, resulting in verbatim and non-verbatim transcribed interviews and field notes (e.g. see DiCicco-Bloom and Crabtree 2006) spanning a total duration of more than 92 hours. Some participants were available for multiple interviews. Most study participants can be described as (co)-founders, investors, and executives working in early-stage startups focusing on robotics, automation, and prefabrication (Table 2). Most participants identified as having a professional background related to the construction industry.

Interview protocol

The interview protocol was pilot-tested using purposive sampling with a small subset of subject matter experts (n = 6) to pinpoint the essential types of information required, including the significance of events, attributes, and experiences, perceptions regarding cause and effect, and viewpoints on potentially sensitive issues (Jimenez and Orozco 2021). According to Creswell (2013), this methodological choice allows for a more holistic data collection process, granting the elasticity to explore conversational narratives while maintaining an overall structure. Central to this inquiry is the provision of a "thick description", a concept coined by Geertz (1973), whereby detailed accounts of the collected data are generated (see Appendix B). Table 3 displays an excerpt of the prompts; the complete set can be found in Appendix A.

Interview coding

The coding procedure adopted in this study reflects the methodology Javernick-Will (2009) used in an interview study with a similar cohort size. Multiple data readings were initially required to comprehensively understand the content (familiarization). This process was followed by generating initial (open) codes, where significant and insightful data segments are marked with descriptive labels (Charmaz 2014). 2998 data segments, including phrases and paragraphs, were coded from the interview data. To analyze this qualitative data from transcribed interviews and field notes (Kuckartz and Raediker 2019), computer-assisted qualitative data analysis software MAXQDA Analytics Pro 2022 was used. Such software tools can assist in organizing, categorizing, and analyzing the data more efficiently and rigorously (Gibbs 2007).

The coding lays the foundation for incremental theme identification, examining patterns and correlations among various codes and categories (Reyes *et al.* 2021). Each emerging theme underwent a review process to ensure accuracy in reflecting the coded data. Subsequently, distinct and descriptive names were assigned to each theme to facilitate identification, resulting in dozens of working themes. These themes were separated to align with the two logics and further grouped to focus on differences and structural overlaps (n = 6).

Table 3. Excerpt of interview prompts.

Interview Prompts for Founders	*How would you define your most significant scaling challenges as a firm?*
	How have your funding needs changed over time?
	How do you find the right investor?
Interview Prompts for Investors	*What is your motivation to invest in construction technology?*
	How do you find the right ventures to invest in?
	What are the limitations or pressures of your investment strategy?

Findings

The thematic analysis identifies six enablers of misalignments, each supported by key quotes and discussed in this section. Complementing this analysis, Table 4 synthesizes these misalignments across their enablers and dimensions and summarizes the findings. More comprehensive empirical evidence on the misaligned dimensions is detailed in Appendix B.

Further guided by the principles of abductive reasoning, systematic combining attempts to contextualize the empirical findings with existing theory. As such, the preliminary mapping within Table 4 aligns the identified misalignments with characteristics of institutional logic (Thornton *et al.* 2005).

Enablers of misalignment

Cognitive frames

Founders and investors varied their beliefs, values, and business practices. The differences reflect the professional culture, pace, and methodology with which each party operates and makes decisions. *"The biggest hurdles we face are the internal disconnects between the organizations"*, a later-stage founder highlighted, illustrating the impact of diverse backgrounds on operational coherence and effectiveness. Furthermore, the challenge of aligning these varied perspectives is underscored by another founder who asserted, *"I can tell you that fundraising is a full-time job"*, pointing out the significant dedication and effort required to bridge this gap.

Table 4. Empirical findings and relation to the characteristics of institutional logic based on Thornton *et al.* (2005).

Enabler of misalignment	Misaligned dimension	Economy logic	technology logic	Findings	Characteristics of institutional logics
Cognitive frames	Customs	Fast-paced	Cautious	Founders' cautious approach aims to carefully navigate market dynamics to build a solid foundation for long-term growth. Investors' fast-paced approach seeks to scale the venture to achieve financial targets rapidly	*Sources of Identity*
Time horizons	Scalability	Scalable solutions	Custom solutions	Founders prioritize meeting the specific needs of their target market, even if it means slower growth or higher initial costs. Investors often prioritize rapid growth and scalability to achieve a quicker return on investment	*Basis of Strategy, Structural Overlap*
	Exit	IPO, acquisition	Often unclear	Founders are more emotionally invested in the company and its mission, making the idea of an exit less appealing or clear. Investors are financially driven and have a clear goal of exiting through profitable channels like IPOs or acquisitions to achieve a return on their investment	*Basis of Strategy, Event Sequencing*
Market strategy	Market	International	Regional	Founders' regional focus reflects a relationship-oriented approach to market engagement, aiming for a deep understanding and strong local presence. Investors' international focus reflects a strongly growth-oriented approach, aiming to capitalize on a broader range of market opportunities	*Economic System, Basis of Attention, Event Sequencing*
	Research	Demand-pull	Technology- push	Founders' technology-push approach can be seen as more visionary, as it seeks to create new market opportunities through technological innovation. Investors' demand-pull approach can be perceived as more pragmatic, as it aims to address existing market demands with targeted innovations	*Economic System, Logic of Investment*
Product vs. Revenue	Product	Asset-light	Capital intensive	Founders' preference for capital-intensive models reflects a longer-term vision of delivering high-value solutions and a willingness to invest heavily upfront to build a strong market position. Investors' preference for asset-light models demonstrates a focus on financial efficiency and quicker market scalability	*Sources of Identity, Basis of Mission*
	Revenue	Fast return	Steady return	Founders' preference for a steady return reflects a sustainable approach to business growth, with a willingness to invest in building a solid market position. Investors' preference for a fast return reflects a more short-term, financially driven approach aimed at quickly recouping investment and generating profits	*Economic System, Basis of Strategy*
Risk tolerance	Risk	High-risk	Medium risk	Founders' risk stance balances growth aspirations with risk management to ensure their venture's long-term viability. Investors' high-risk stance reflects a more aggressive, return-maximizing approach, aiming to capitalize on high-reward opportunities, even if they come with a higher degree of uncertainty	*Basis of Attention*
	Focus	Diversified	Concentrated	Founders' concentrated focus reflects a strategic choice to dive deeply into their domain, ensuring excellence, relevance, and competitive advantage. Investors' diversified focus reflects a strategic choice to spread risk and seize a broader spectrum of opportunities, aiming for financial robustness	*Sources of Identity, Structural Overlap*
Information asymmetry	Innovation	Incremental	Systemic	Founders' preference for systemic innovation reflects a willingness to achieve transformative outcomes driven by a long-term vision of market disruption or significant societal impact. Investors' preference for incremental innovation aims to steadily enhance market position and ensure a reliable return on investment	*Sources of Legitimacy, Basis of Mission, Logic of Investment, Institutional Entrepreneurs*
	Intellectual Property	Less essential	Essential	Founders' emphasis on IP indicates a vision to build a solid foundation for their venture's competitive position, valuing the protection and potential market exclusivity that IP can provide. Investors' lesser emphasis on IP reflects a more immediate focus, potentially viewing IP as a secondary concern	*Sources of Legitimacy*

Time horizons

A significant discrepancy is evident in how founders and investors conceptualize time horizons regarding the rate of robotic technology adoption within the construction sector. *"I can't even think of five people with robotics experience in the construction space that can pull something together today"*, an investor admitted, revealing a gap in expectations and mutual understanding of the required timeline for technology adoption and scalability. A founder questions, *"Are we in the construction industry not innovating enough ourselves, or are we being disrupted by outsiders?"* reflecting on the industry's internal versus external sources of innovation.

Market strategy

Misalignments in market strategy reflect the two stakeholders' varying understandings of market dynamics, customer needs, and industry trends. *"Investors often confuse their needs with the customer's, placing their own needs above customer feedback"*, one founder emphasized, showcasing the misalignment in priorities between founders and investors. Additionally, an investor stated, *"We need some kind of education for people investing in the space, as well as people around the space just to know that construction robotics is going to be different from other types of robotics and we really can't make that comparison in terms of exits and comparables"*, indicating a notable difference in market strategy focus for robotics in construction. On the other hand, investors are energized by seeing the rise of *"New Age Construction Firms"*. One investor captures the sentiment: *"I believe new players are coming in - not threats - but new players"*, signaling a welcome wave of fresh ideas and innovation.

Product development vs. Revenue generation

Another tension exists between the qualitative and quantitative perspectives that impact each party's strategic decisions regarding the nature of the products or services the ventures aim to deliver. *"If you develop hardware things like robotics, then VC may not even be the right thing to do at the beginning"*, a founder assured, pointing out the conflict between product innovation and early revenue generation. *"Venture capital, as it's currently practiced, isn't necessarily the best model"*, an investor voiced, and that *"it can lead to inefficiency and isn't always beneficial for the broader economy"*, echoing concerns about the focus on revenue over product development.

Risk tolerance

Founders and investors are willing to take different levels of risk in pursuing their objectives. *"After all, management is where the mistakes are made, and the significant wins and losses are scored"*, an investor recognized, pointing out the divergent approaches to risk and the impact of decision-making under uncertainty. Regarding risk appetite, one investor pointed out that *"we want to make sure that we're making the best investments, but we also understand that there's actually a lot more great companies out there than we can even invest in ourselves*", indicating that opportunity cost is strongly related to making selective, informed decisions amidst many opportunities.

Information asymmetry

Founders and investors often approach decision-making with differing scopes and granularities of information, leading to divergent perspectives. A founder advised, *"Startups should conduct due diligence on the investor, looking into their portfolio companies - and understand what they offer besides money"*, highlighting the importance of overcoming information asymmetry through thorough research and strategic communication. Eventually, a founder stated, *"I believe it's not about how much money you've got. We bootstrapped for 18 months. An excess of money can make a founder lose focus, less money keeps you centered"*, which challenges the notion of abundant venture capital funding, proposing that a more modest approach can be tempting for the organization.

Relation to the characteristics of institutional logics

This section presents the findings related to the established characteristics of institutional logic, as seen in Table 4 (Thornton *et al.* 2005). The economic system in construction robotics is driven by market competition (with existing solutions in construction), the pursuit of innovative research and development (to increase novelty and competitiveness), and the imperative to generate revenue and profit, mainly from the investment side). Organizations derive their identity from the traditional customs of their respective institution, which are mirrored in the products and services they develop. Legitimacy is generally gained through deploying innovation in pilot projects and protecting intellectual property. The organization's strategy revolves around scalability, exit strategies, and investor profit maximization, and the economic logic prioritizes R&D and innovation as key growth drivers. Institutional entrepreneurs promote innovation within and across institutions. These dimensions can sometimes be at odds, such as when pursuing profit compromises investment in long-term R&D or when market pressures conflict with the organization's innovation agenda.

Misalignment occurs when these sources pull in different directions, for example, when market demands shift away from the products central to an organization's identity. Furthermore, the misalignment of product development priorities complicates this situation. In this scenario, investor needs can overshadow customer feedback, exacerbating the challenges of pursuing innovation that conflicts with existing market norms or strictly allocates resources to intellectual property, stifling collaboration and open innovation. Misalignment can occur when product development goals do not align with the innovation agenda, potentially leading to strategic drift or resource misallocation. Conflicts arise when focusing on exit strategies and short-term profits undermines efforts to scale operations sustainably. Misalignment is evident when short-term financial pressures compromise long-term investment in innovation and when their innovation agenda conflicts with established institutional norms and practices. The sequence of key events, such as exit strategies and market entry, plays a critical role.

Lastly, structural overlap involves aligning organizational scalability and strategic focus. For instance, unclear regulations and standards can hinder certainty for firms in this sector, one example being concrete 3D printing technology. Additionally, the need to balance fundraising efforts and operational management is amplified by companies' internal challenges, often magnified by the pressures of aligning (external) investor and (internal) founder visions when market sizes and growth rates are uncertain. Organizations' attention is allocated to market trends and risk management. Eventually, the founder-investor relationship, further strained by differing visions on product development and operational management, can create a cascade of inefficiencies reflecting misaligned priorities.

Discussion

Implications for construction technology adoption

While centered on construction robotics, this study highlights broader institutional dynamics that impede the adoption of technologies and novel methods within the construction industry. These dynamics can manifest as conflicting logics, such as those related to Building Information Modeling (BIM), efficiency, sustainability, and aesthetics (Thornton *et al.* 2005, Linderoth 2017, Gluch and Hellsvik 2023). In fact, the enablers of misalignments identified in this study can be traced to the unique characteristics and context of the construction industry itself.

Cognitive frames

Stakeholders in the construction industry utilize cognitive frames, mental models, and assumptions to interpret and understand new technologies. These frames significantly shape technology perception and adoption. A strong adherence to traditional practices and a preference for proven methods can result in cognitive frames that resist change. This resistance contributes to institutional misalignment, wherein new technologies conflict with established norms and practices. Such misalignment can explain the distinct challenges faced in adopting robotics in construction compared to industries more receptive to innovation (Lundberg *et al.* 2022).

Time horizons

Due to their temporary nature, construction projects typically operate on short-term time horizons. This focus on immediate project costs and benefits impacts the potential long-term advantages of investing in technologies. The industry's short-term orientation poses a significant barrier to adopting technologies requiring a longer-term perspective to realize full benefits (Gottlieb and Haugbølle 2013). This temporal misalignment between project timelines and the lifecycle of technological adoption is a critical factor in understanding the industry's low appetite for innovations.

Market strategy

Adopting new technologies can be a strategic endeavor for firms aiming for differentiation or enhanced efficiency. However, market strategies within the construction industry are distinct from other sectors, primarily due to the need to balance innovation with cost control. The industry's typically low margins and competitive nature often discourage investment in new technologies, emphasizing a conservative approach (Barbosa *et al.* 2017). This context highlights the institutional factors that hinder technology adoption and innovation.

Product vs. Revenue focus

A significant tension in the construction industry lies between the focus on the product (e.g. the building or built environment) and the revenue generated (e.g. from components or subcontracted services). This distinction impacts the industry's willingness to adopt new technologies, which may entail higher initial costs without immediate revenue benefits. This tension also highlights the challenge of balancing costs and profitability, affecting decision-making processes and creating potential barriers to technology adoption (Kangari and Halpin 1990, Sawhney *et al.* 2020).

Risk tolerance

Due to high costs, complexity, and potential financial losses, construction firms generally exhibit low-risk tolerance. This cautious approach often leads to a preference for established technologies and methods, making it difficult for innovative solutions to gain traction. This low-risk tolerance contributes to institutional misalignment, as firms resist adopting new technologies perceived as risky (Katila *et al.* 2018, Polzin *et al.* 2018).

Information asymmetry

The construction industry is characterized by information asymmetry, where stakeholders, clients, contractors, and suppliers possess varying levels of information and expertise. This uneven distribution can lead to misunderstandings or mistrust regarding the benefits and risks of new technologies. As a result, information asymmetry can act as a barrier to innovation adoption, complicating decision-making and alignment among stakeholders. This issue is particularly relevant in construction, where complex projects involve multiple parties with diverse interests and perspectives (Bosch-Sijtsema *et al.* 2021, Lideloew *et al.* 2023).

Institutional challenges and opportunities in construction robotics

Our findings reveal several challenges and opportunities in the organizational field of construction robotics. The integration of systemic innovation requires shifts in practices, often highlighting tensions between technological potential and economic goals (Sheffer *et al.* 2013, Bosch-Sijtsema *et al.* 2021). Notably, construction robotics amplifies existing institutional barriers such as the sector's fragmentation and inherent resistance to change.

Our findings align with previous research (Katila *et al.* 2018, Sawhney *et al.* 2020) in demonstrating that the effective integration of construction innovation necessitates substantial changes in workforce skills, regulatory frameworks, and management practices. However, our study deepens this understanding by drawing directly from the empirical context of construction robotics, revealing new insights into the unique challenges and opportunities within this field. For instance, implementing construction robotics may necessitate new training programs to develop specialized skills among the workforce, alongside updated regulations to ensure safety and compliance. While management practices may need to adapt to robotic systems' new workflows and operational dynamics, it is equally important to consider how robotics can be developed to align with existing management structures. This reciprocal approach could lead to more sustainable technology integration within construction operations, allowing for innovation and the maintenance of existing management practices. Furthermore, the emergence of construction robotics introduces challenges and opportunities related to innovation diffusion. While increased efficiency and reduced labor costs offer clear benefits, the construction industry's conservative nature and fragmented structure present significant challenges (see also Dubois & Gadde, 2002b, Manley & McFallan 2006, Bademosi & Issa 2021). The following sections will discuss the empirical results suggesting that misalignments in the industry can act as both obstacles and enablers, ultimately leading to the development of new practices in construction robotics.

Misalignments as a "Bug"

Multiple and sometimes conflicting logic (Aldrich and Fiol 1994) are navigated by new technology-based firms in construction. The empirical data from construction robotics reveals that misalignments in institutional logic are a source of frustration and conflict, loosely mirroring the findings in the context of new industry creation by Hargadon and Douglas (2001). Such misalignments can force founders to diverge from their operational focus in pursuit of venture funding, a process that can be viewed as a "bug" in the entrepreneurial journey (e.g. Sarasvathy 2001). Such diversion strains the founder-investor relationship and amplifies the conflicts between the pursuit of immediate profit and the commitment to long-term research and development. Founders must align investor expectations with their strategic vision for innovation and sustainable growth. Furthermore, the higher the information asymmetry between founders and investors regarding the capabilities and limitations of construction robotics, the greater the potential for investment inefficiencies, negatively affecting the emerging organizational field.

Misalignments as a "feature"

Understanding misalignments in business relationships involves recognizing that they are not inherently and exclusively harmful. Instead, they offer insight into the complexities of human perceptions and beliefs and enriching the comprehension of stakeholder interactions. Therefore, an alternative understanding of these misalignments can also be interpreted as a helpful feature or benefit. For example, a financial misalignment can foster focus and operational efficiency in the investor-investee dyad in construction robotics, similar to the ethos of "bootstrapping".

Furthermore, the arrival of professionals from varied industries into construction leads to a vital discourse on possible innovation within the sector. This scenario suggests a productive challenge, where the industry's traditional offerings are challenged by novel approaches and solutions brought in by these new entrants. Investors' optimism reflects the potential to drive construction robotics, recognizing the available opportunities and suggesting that frictions do not necessarily impede the pursuit of worthwhile investments.

Corsaro and Snehota (2011) suggest that when acknowledged and understood, misalignments in business relationships can be harnessed to strengthen partnerships, particularly when they encourage open communication and are free from rigid constraints. Paradox theory in organizational studies has pointed to an equilibrium model that depicts how cyclical responses to paradoxical tensions enable future success (Lewis and Smith 2000, Smith and Lewis 2011).

Korber *et al.* (2022) identified three responses of entrepreneurs to misalignments: "enduring" due to geographic ties, "escaping" to seek opportunities elsewhere, and "engaging" to constructively navigate and reconcile differing institutional logics by fostering new organizational fields. As such, positive transformations can arise from misalignments when stakeholders view them as opportunities for synergy rather than conflict. Therefore, misaligned institutional logic can reshape the entrepreneurial ecosystem's systemic and infrastructural conditions in the organizational field of construction robotics, which may be aided by the findings of this study. Eventually, how stakeholders respond to misalignments is pivotal for nascent and emerging organizational fields (Thornton *et al.* 2012, Gottlieb and Haugbølle 2013). After all, innovation is a process by which institutions are disrupted and overturned, giving way to new institutional forms (Scott 2013).

Towards a new practice

As the organizational field of construction robotics progresses toward increased formalization, it will intersect with or operate alongside several established institutions (Williamson 2000, Kraatz and Block 2008, Hall and Scott 2019). This process of co-constitution, potentially unfolding over decades, can showcase the emergence of standardized practices through continued interaction within the emerging organizational field of construction robotics. Previous research on the early institutionalization of integrated project delivery (IPD) (Hall and Scott 2019) highlighted this process as a gradual, co-evolutionary journey rather than a static outcome. Consequently, this co-constitution could signal the emergence of new practices (Graser *et al.* 2021) in construction robotics and warrants further longitudinal observation and ethnographic study.

A critical issue in these misalignments arises from conflicting priorities between investors and founders, diverting strategic focus and stalling innovation (Aldrich and Fiol 1994, Sarasvathy 2001). However, these misalignments also present an opportunity to enhance operational efficiency and drive innovation through diverse stakeholder perspectives and adaptive strategies (Corsaro and Snehota 2011). Effectively recognizing and managing these institutional misalignments can transform the entrepreneurial ecosystem in construction robotics, fostering a more innovative and resilient field. This co-constitution process within construction robotics highlights the complex interplay of institutional logic shaping new practices. As depicted in Figure 4, this figure illustrates the institutional dynamics within construction robotics, highlighting how the two dominant institutional logics can lead to the co-constitution of a new practice. The figure presents a conceptual framework for developing construction robotics, highlighting the interaction between economic and technological logic mediated by human agents. Venture capitalists influence and are influenced by economic considerations, shaping investment decisions in robotics; entrepreneurs are aligned with technological logic, bridge advancements with market opportunities, and drive commercialization and adoption.

Central to this framework is the concept of longitudinal co-constitution, emphasizing the ongoing, mutual influence between economic and technological logic. This process suggests a more iterative approach to innovation. Construction robotics, as the central innovation, has the potential to transform workflows, labor dynamics, and productivity in the construction industry, establishing new practices and advancing the role of automation over time.

Limitations

Institutional logic provides a robust framework for analyzing organizational behavior but also has limitations. The term "logic" suggests a level of coherence

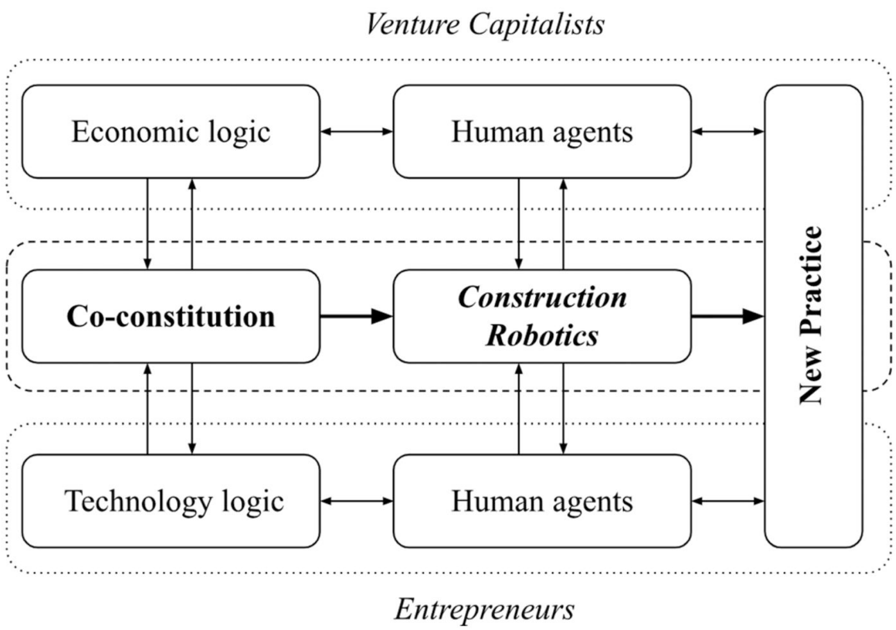

Figure 4. Co-constituting existing institutional logic leading to a new practice.

that only sometimes exists within or between institutions, leading to a risk of oversimplifying complex motivations and organizational actions (Pache and Santos 2010, McPherson and Sauder 2013). Moreover, the focus on macro-level institutional constraints might also obscure the role of individual agency, overlooking the potential of individuals or organizations to act as "institutional entrepreneurs" capable of effecting change (Emirbayer and Mische 1998, Battilana *et al.* 2009). Evidently, organizations with more precisely defined goals or better-developed technologies are less subject to institutionalization than those with diffuse goals and weak technologies (Selznick 1957), suggesting a need for more sophisticated institutional approaches that accommodate multilevel causal processes (Williamson 2000).

While institutional logic offers descriptive richness, it requires more prescriptive utility, as identifying multiple logics does not necessarily translate into actionable strategies for organizations to navigate or "inhabit" these logics (Hallett and Ventresca 2006). Additionally, the study's strict reliance on typologies and binary categorizations risks neglecting the diverse lived experiences and practices where such logics are enacted (Pache and Santos 2013).

While this study employed institutional logic as a lens to examine the empirical data, it remains unclear to what extent the suggested logics apply. Further, using systematic combining, there is more than one way to combine empirical data and theoretical frameworks (Dubois and Gadde 2002b). Lastly, there is a remaining gap in institutional logic around understanding and evaluating the sources of authority and governance mechanisms in the context of construction robotics firms, an opportunity for future research.

Future research

This study enhances the understanding of investor-investee dynamics within construction technologies, specifically using construction robotics as the empirical case and institutional logic as the analytical lens. Several areas require further exploration to expand our findings' theoretical and practical implications.

Firstly, future research can focus on the influence of cultural, political, and economic contexts on these dynamics. Given the diverse geographical settings from which our data were aggregated, there is an opportunity to examine how regional factors uniquely affect investor decisions and project outcomes in construction technology. Comparative studies across different countries could surface distinct patterns and strategies, providing a more refined understanding of the global landscape.

Secondly, while our analysis primarily centers on the investor-investee dyad, expanding the scope to include other stakeholders is crucial. This includes exploring the roles of business angels and examining clients and partners along the value chain. These stakeholders are instrumental in the diffusion and adoption of construction technologies, yet their contributions and interactions remain underexplored. Employing methodologies such as single case studies, mixed methods (Polzin *et al.* 2018), or quantitative approaches (Tidhar and Eisenhardt 2020) could offer deeper insights into these complex relationships.

Moreover, the inconsistencies between and within social and cultural systems, as highlighted by Seo and Creed (2002), deserve further investigation. Future research could benefit from ethnographic methodologies and secondary data analysis to capture the subtleties of these interactions and their long-term effects.

Lastly, exploring the "shadow of the future" concept (Axelrod 1984) through individual-level case studies could provide valuable insights into stakeholders' emotions and expectations. By examining how anticipation of future interactions influences behavior and decision-making, researchers can better understand the norms of institutional reciprocity (Scott 2013) and their implications for construction technology partnerships. This approach could examine the long-term impacts of institutional misalignments among stakeholders, offering critical insights for theory and practice.

In summary, future research can build upon this study's findings by investigating the specificities of construction technologies in various contexts. Such work can further contribute to developing more effective investment strategies within the organizational field of construction robotics and more generally, with and for construction technologies.

Conclusion

This study investigates institutional misalignments among key stakeholders in construction robotics, an area largely unexplored in construction management research. Our analysis identifies six key enablers of misalignment in the construction industry: differing cognitive frames, divergent time horizons, conflicting market strategies, a focus on product versus revenue, varying risk tolerances, and information asymmetry. These enablers emphasize the deep institutional and operational challenges rooted in the construction industry's conservative nature and fragmented structure, which impede the adoption, implementation, and diffusion of innovative technologies such as robotics.

Accordingly, addressing these misalignments demands a sophisticated strategy integrating the construction industry's unique characteristics with broader institutional logic. Shifting cognitive frames toward a more innovation-friendly mindset and aligning short-term project goals with long-term technological investments are pivotal strategies for overcoming resistance to new technologies. By highlighting these critical issues, this study deepens the understanding of institutional dynamics within the construction sector, setting the stage for future research to develop targeted interventions.

The systematic combining approach used in this case study of construction robotics has provided both specificity and generalizability to our findings, supported by comprehensive empirical data. Our analysis suggests that institutional logic in construction robotics may lead to co-constituting new practices, offering insights into the adoption processes of other high-tech construction innovations. However, further research, particularly longitudinal and data-centric studies, is needed to determine whether these misalignments represent temporary challenges ('bugs') or inherently positive aspects ("features") of the emerging organizational field of construction robotics.

Ultimately, these findings emphasize the urgent need for the construction industry to adapt workforce skills, regulatory frameworks, and project management practices to better align with technological advancements. Addressing institutional misalignments is crucial for the industry to effectively respond to increasing societal and environmental demands and fully harness the potential of emerging technologies.

Missing due to blinded review:

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Authors' Contributions

Conceptualization: ANW, DMH; Methodology: ANW, DMH; Validation: ANW; Formal Analysis: ANW, TT, KG, DMH; Investigation: ANW, DMH; Resources: ANW, DMH; Data Curation: ANW; Writing (Original Draft): ANW; Writing (Review & Editing): TT, KG, DMH; Visualization: ANW; Project Administration: ANW, DMH; Supervision: DMH.

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Data availability statement

Due to ethical restrictions, the raw data is not available. Aggregated data may be available from the authors upon reasonable request.

Notes

1. In engineering disciplines, a 'bug' signifies a flaw requiring correction, while a 'feature' is a beneficial function. Interestingly, bugs' first and second-order effects can sometimes result in features. First-order effects are the immediate consequences of a bug, such as a system malfunction. Second-order effects are the subsequent impacts that occasionally lead to unintended beneficial functions or innovations. One of the most famous anecdotes related to the term 'bug' involves Grace Hopper, a pioneer in computer science, in the 1940s. While working on the Harvard Mark II computer, her team discovered a malfunction caused by a deceased moth trapped in the system. They removed the deceased bug and humorously noted that they had 'debugged' the machine. This incident popularized the term 'bug' in the context of computer science and highlighted the ongoing challenges of troubleshooting and correcting system flaws (Wills 2022). In addition, this study also acknowledges the Kafkaesque journey faced by some participants, echoing Kafka's depiction of a protagonist's abrupt transformation into a bug (Kafka 1915). This shift illustrates the confusion in modern labor and market systems, where individuals face rapid changes beyond their control. Consistent with the Austrian school of economics, this view highlights the subjectivity of personal experiences.
2. Arguably, these assumptions are overly simplistic and predominantly U.S.-centric. Incorporating global data could potentially adjust the figures downward significantly.

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Appendix A

Table A1. Interview prompts for founders.

Aim	Interview Prompts for Startups
Personal description of individual's lived experience and professional environment	What is your role in your firm, and what problem is the firm solving?
	What motivated you to found or join the company you work at?
	Why are you operating in the construction sector?
Role of Hardware	What is the role of hardware technologies in your firm?
Role of Software	What is the role of software technologies in your firm?
Scaling Challenges	How would you define your most significant scaling challenges as a firm?
Funding Situation and Strategy	How is your Start-Up funded?
	How have your funding needs changed over time?
	What are the benefits of your current funding strategy?
	What are the limitations or pressures of your funding strategy?
Investor relationship	How do you find the right investor?
	How would you describe the relationship with the investor(s)?
Next steps	What are your next steps as a firm?
Snowball-Sampling	Can you recommend firms that we should speak to?

Table A2. Interview prompts for investors.

Aim	Interview prompts for investors
Personal description of individual's lived experience and professional environment	What is your role in your firm, and what problem is the firm solving?
	What motivated you to found or join the company you work at?
	Why are you investing in the construction sector?
Hardware investments and expectations thereof	Have you invested in hardware technology startups in AEC?
	What is the motivation to invest in such technology?
	What are your expectations of such an investment?
Software and Hardware Investments	Do you have similar expectations for Software and Hardware?
	Can you describe the differences, if there are any?
Deal sourcing/flow	How do you find the right ventures to invest in?
	At what stage do you invest in those firms?
Funding Strategy	What are the benefits of your investment strategy?
	What are the limitations or pressures of your investment strategy?
Investee relationship	How would you describe the relationship with your portfolio firms?
Next steps	What are your next steps as a firm?
Snowball-Sampling	Can you recommend firms that we should speak to?

Appendix B

Customs

This section presents behavioral and decision-making approaches that founders and investors exhibit while advancing the venture. Founders usually take a more cautious approach, carefully considering each step as they navigate the market challenges. Founders are aware and voiced that *'customers want practical solutions, while investors look for business models they're familiar with'*. Founders are closely involved with daily operations and are keen to make decisions that ensure steady and sustainable growth in the long run. Overall, they typically regard robotic technology as a tool and an instrument for transformative societal change. Generally, founders also commit to incorporating sustainability and ethics as integral components of their business strategies. A founder remarked, *'Capitalism always wins, even if the planet dies. Is that a good thing? Not for me'*. However, another founder explained that *'as of today, I believe that you can't make much money with the promise of sustainability itself, but that it's more of a permission to operate in the future than a real product today'*.

On the other hand, investors perceive that they are *'very practical on the sustainability technology side of things. It seems everyone's talking about it, but no one's doing anything about it. Now tell me, can it be profitable?'* This is one of several examples indicating that investors adopt a fast-paced approach driven by financial objectives and extensive market data. Their focus predominantly lies on tangible metrics, showcasing a more utilitarian approach in their strategic outlook. Investors stated that *'the total addressable market is a figure we don't look at. It can be misleading. We prefer to look at growth rates instead'*. This indicates that investors are heavily concerned with metrics that indicate the startup's expansion and revenue generation potential. Some investors *'believe that the trend is towards more and more data science being used to fish out relevant investment opportunities'*. Contrary to that, founders voiced their critique by asking, *'If you don't have volume what do you want to scale for?'*

These misalignments challenge collaborative efforts, potentially leading to friction from the start of the business relationship due to misaligned partnership expectations. The divergence in cultural norms and philosophical customs also becomes particularly striking when considering the temporal aspects.

Scalability

This section concerns how easily a product or service can be expanded or adapted to meet growing demand or a more extensive user base. Founders often have a deep understanding of their target market and the unique problems it faces. They prefer creating custom solutions tailored to these specific needs, which can help build strong relationships with customers and establish a solid reputation in the market. However, custom solutions are less easily scalable as they are designed for a specific problem or market, making them potentially time-consuming and costly to adapt for broader markets. An investor remarked that they would *'start with building the product for the existing customer already'*. Additionally, founders are inherently optimistic about the transformative capabilities of their products, often interpreting their innovations as catalysts for rapid technological acceptance. As an investor explains, this increases the pressure between the two parties since *'the expectation about the return on investment in hardware and robotics, of course, always has to be similar to software companies'*.

Investors seek a high return on investment within a relatively short time frame. One explained that they *'never want to invest heavily in custom hardware. It's not scalable'*. Investors prefer scalable solutions that can be quickly and cost-effectively expanded to new markets or adapted to meet a broader range of needs, increasing the potential for rapid growth and higher returns. As one founder explained, *'if you don't have software you don't have a company'*. However, such scalable solutions can not address the specific needs of a particular market as precisely as custom solutions. Still, they offer the advantage of faster expansion and a quicker return on investment through an exit event.

Exit

'Exit' in this section refers to the strategies concerning how founders and investors plan to exit the venture to achieve liquidity on their investments. Founders primarily focus on growing the company, solving market problems, or achieving a vision. They might not have a clear exit strategy, as their primary concern is the company's long-term business sustainability and growth. The idea of exiting can even be secondary or not a priority, particularly if founders are deeply invested in the company's mission. For example, some founders embody strong resilience *'despite venture capitalists suggesting a pivot to another industry'*.

On the other hand, investors' perspective is financially driven, and having a clear exit strategy is crucial for realizing financial returns. One investor clarified their standpoint by stating, *'We have to believe that any one investment, if they're really successful, could stake in them as a fraction of their value at the time they exit, either by acquisition or IPO, should return our entire fund'*. Put simply, investors prioritize actions that position their ventures favorably for an IPO or acquisition. They are convinced that *'fully autonomous construction sites may still be 30 years away but electrification can happen today!'* Such a time frame is out of scope as *'the 'valley of death' in robotics is a problem for VC. It takes too long as we only have a 10-year fund'*.

The misaligned temporal dimensions require critical attention from founders and investors, which can significantly impact a venture's long-term success. Discrepancies in differing time horizons further contribute to the misalignments in market strategy.

Market

Here, the dimension of 'market' refers to the geographical focus and market reach that founders and investors target for the venture. Founders often lean towards a more regional-centric approach in their market strategies. As one founder explains, *'the problem is that there are different standards, not only internationally, but also at national level, and that makes it extremely difficult to expand'*. Their close ties to the local ecosystem prompt them to shape their strategies to meet the particular demands and dynamics of the regional market. Engaging with local customers, suppliers, and other stakeholders allows them to understand better the regional market terrain, which in turn influences their strategic decisions and the design of their products or services. Driven by a universalist ideology, some founders assume that a product's triumph in one market is a reliable predictor of its potential success in other markets. This ideological stance can obscure new markets' cultural, economic, and social intricacies, potentially hindering a refined market entry strategy. Some founders agree that *'it's a race to find, which is the right fit of the product, which is the right fit of the robotics industry within the construction industry'*.

On the other hand, investors typically apply a more international or global outlook, as one of them states, *'We are also interested in recognizing trends that are emerging in a certain geography at an early stage, and then being able to take this learning and implement it in other geographies'*. Enriched by their exposure to various markets, they employ a more relativist approach, underscoring the necessity to tailor strategies to global conditions and more general norms. Their extensive market experiences and financial objectives drive them to explore opportunities beyond geographic borders, aiming to scale into diverse markets to optimize return on investment. With this global lens, investors emphasize adaptability, promoting strategies promising international market penetration and growth.

As such, depending on R&D efforts, the emphasis can be on advancing technology for new market introduction or responding to existing market demands with novel solutions.

Research

Founders often lean towards a technology-push approach, driven by the belief in creating innovative technologies that can open up market opportunities or create new market segments. As one founder explained, *'to do a thing once vs. doing it 200 times over is a whole different challenge'*. They aim to invest in research to develop pioneering technologies or products, anticipating that these innovations will create demand once introduced to the market. This approach originates from deep technical expertise or a visionary outlook on how technology can address future market needs. However, some founders are skeptical as *'thinking too much about technology can be misleading; it's not the challenge. Once you know what to build, it can be figured out'*.

On the other hand, investors usually favor a demand-pull approach driven by the existing market demands and customers' needs. As such, one explains that *'we don't need more complex technology; we need simpler technology that performs better than existing solutions'*. Investors prefer investing efforts that respond to clear, identified market needs or demands, aiming for quicker market adoption and, thus, return on investment. This approach is considered lower risk than the technology-push strategy, as it's based on responding to market needs rather than attempting to create entirely new market segments.

The scope of market engagement significantly impacts the venture's strategic decisions, resource allocation, and growth trajectories. The discrepancies in market strategy further relate to and impact product development and the need to achieve early profitability.

Product

Here, the findings suggest misaligned milestones, with founders prioritizing product-centric assets and objectives, while investors prefer asset-light and scalable business models. Founders often lean toward developing capital-intensive products or services, which require substantial investment in assets, technology, or infrastructure upfront. In one example, a founder explained that *'we realized that the CAPEX [capital expenditure] was just out of control. You would have not been able to fund it on your own, so you need VC; there is no way around it'*. Founders see these products or services necessary to deliver high value, differentiate from competitors, or address complex market needs. The focus on capital-intensive offerings stems from a desire to build a strong, sustainable competitive advantage, albeit with higher initial investment and potentially longer-term returns. Founders are convinced that *'one of the beautiful aspects of robotics is that it's a data magnet, constantly improving as we continue deploying it in projects'*.

On the other hand, investors prefer asset-light models, which require less capital expenditure upfront and have lower fixed costs. As an example of the investors' stance, *'the goal is to build something simple, not a complex solution. People don't understand all these [technology] overkills and that doesn't help adoption. It is really about product complexity vs. industry adoption'*. Asset-light models, such as software or digital platforms, can often scale more quickly and at a lower cost, providing a faster path to profitability and a sooner return on investment. As such, the investors' preference for asset-light models reflects a more financially conservative approach, aiming to minimize financial risks while maximizing the potential for rapid growth and profitability.

Revenue

This section highlights the pace at which founders and investors anticipate generating revenue or profits from the venture. Founders often aim for a steady return, reflecting a more conservative or long-term approach to revenue generation and profitability. They prioritize building a solid customer base, establishing strong relationships, and gradually growing the business to ensure sustainability and steady revenue streams. For example, one founder commented, *'as an early stage founder, I don't need investors, I just need a pilot project. The legal and IP challenges that come with investors can be avoided with the right project'*. This approach focuses on building a lasting business with a stable financial foundation, even if it means slower financial growth, at least initially. To add to this stance, founders believe that *'if you're an entrepreneur that doesn't know the industry it's actually really hard to know where to start. But sometimes not abiding by existing rules can also help innovate a lot'*.

On the other hand, investors prioritize strategies that promise sooner market penetration, rapid customer acquisition, and swift revenue generation, favoring aggressive growth tactics. This approach focuses on achieving key financial objectives. As such, competition also plays an important role. As one of the investors pointed out, *'You need competition, but not ten companies doing the same thing'*.

There appears to be a divergence of opinion concerning revenue, particularly in the context of individual preferences or expectations related to financial return on investment. Eventually, differences in the emphasis on product development and early revenue generation can also hinge on these two stakeholder groups' very different risk profiles.

Risk

An investor stated that *'the building industry is often accused of being hostile to innovation, but in my opinion, it is not at all. It's just a very clever risk assessment'*. Accordingly, founders in this industry exhibit an overall medium level of risk tolerance, seeking a balanced approach to risk-taking that aligns with their venture's long-term sustainability and growth. They prefer strategies that entail a manageable level of risk, allowing for steady growth and a controlled approach to navigating market challenges. This moderate risk appetite reflects a focus on building a solid foundation for the venture, ensuring its resilience and sustainability over time. They exhibit a form of resilience and tenacity that allows them to remain committed to their ventures.

Investors display a higher risk tolerance, driven by the potential for higher returns on investment. They are willing to pursue aggressive growth strategies, venture into global markets, or invest in innovative yet unproven technologies to achieve a competitive advantage and accelerate financial gains. As one investor stated, their perspective is that *'the game is about how to survive technology cycles and economy cycles. You want to perform well on the intersections'*. This higher risk tolerance reflects a focus on maximizing return on investment, even if it entails navigating a more volatile or uncertain business environment.

Focus

Another difference lies in the breadth (or narrowness) of focus that founders and investors exhibit in their strategic approach. This dimension reflects how resources, attention, and efforts are eventually allocated toward either a narrow or broad range of activities, markets, or product lines.

Founders exhibit an intensely concentrated focus, perfecting a specific market, product, or service line to ensure relevance and build a solid competitive position. They believe that a concentrated 'all in' approach allows for deeper understanding, better resource allocation, and a stronger brand identity in the chosen domain. Founders know that *'the biggest problem in traditional construction is the contracting process. It inhibits a significant amount of innovation'*. Therefore, this focused approach reflects a desire to excel in niche market segments like construction robotics, ensuring their venture's robustness and business sustainability.

On the other hand, investors advocate for a diversified focus, encouraging the exploration of multiple markets, product lines, or revenue streams to spread risk and increase the chances of financial success. Often coined as the 'spray and pray' approach, they see portfolio and focus diversification as a means to capitalize on various market opportunities, mitigate risks associated with a single market or product, and achieve a broader customer base. Furthermore, investors are convinced that *'in every stage you need different people, for example in Pre-Seed. Then you have to unlearn, change operations, maybe the team too, then move to the next round. All stages require different activities and knowledge'*. This diversified approach reflects a financial strategy to enhance the venture's resilience to market fluctuations and maximize return on investment.

Risk appetite and tolerance variables influence decision-making, strategic planning, and the approach to pursuing growth opportunities. These discrepancies in differing risk profiles also further contribute to the asymmetry of available information, and perhaps vice versa.

Innovation

This section reflects on the extent and nature of innovation that founders and investors aspire to pursue. It encapsulates the strategic orientation towards making radical changes or pursuing incremental improvements. As one founder points out, *'The biggest risk in technology for construction is that you make a product that's too difficult to integrate, you know, into construction, where you try to reinvent too many processes, all at once'*. Founders often lean towards systemic or radical innovation, which entails a fundamental overhaul or creation of new paradigms in products, processes, or market approaches. They are driven by a vision to significantly disrupt the market or solve complex challenges through groundbreaking innovations.

On the other hand, investors prefer incremental innovation, which involves making steady, step-by-step improvements to existing products, services, or processes. They view incremental innovation as more suitable for constant growth and gradual market penetration. One investor pointed out that *'there just aren't a lot of investors out [t]here that are interested in this space, or that feel comfortable navigating it'*. Another investor said, *'everything in the [Silicon] Valley is about user experience. They say, 'How can we increase the experience by 10x?'. This is very, very difficult in construction. we are looking at extremely long development cycles'*. This approach can be seen as more predictable, as it builds upon existing market acceptance and gradually improves competitiveness.

Intellectual property

There is also a notable difference in how the two parties address the importance and emphasis placed on intellectual property rights and protections. Intellectual property can encompass patents, trademarks, copyrights, and other forms of legal protection for innovations and brand assets. Founders view intellectual property as essential, a critical foundation for establishing a competitive advantage and securing a unique position in the market. They invest significant resources in obtaining IP rights to safeguard their venture's innovations and brand identity. This importance of IP reflects a long-term strategy to build and sustain a strong market position, potentially attracting more customers and partners due to the demonstrated commitment to innovation and quality.

On the other hand, investors view intellectual property as less essential than other factors such as market traction, revenue growth, or customer acquisition. As one investor asks, *'Is it worth going without IP? Startups may need patents to attract investors but it slows them down significantly'*. While investors recognize the value of IP, they prioritize other aspects of the venture that can generate quicker returns on investment. Again, this stance reflects a more pragmatic or financially driven approach, focusing on immediate tangible metrics and outcomes that can accelerate the return on investment.