Licentiate Thesis in Real Estate and Construction Management

# PropTech and Business Model Compatibility in Real Estate Sector

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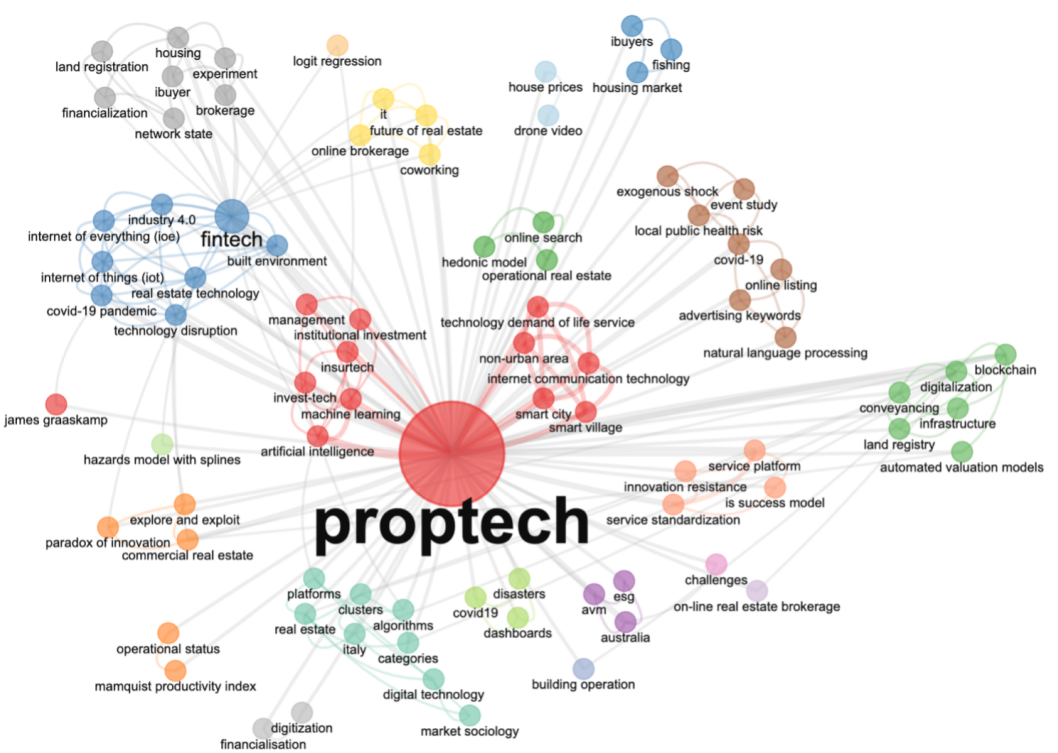
KTH ROYAL INSTITUTE OF TECHNOLOGY



# PropTech and Business Model Compatibility in Real Estate Sector

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# I Abstract

Property Technology (PropTech), a term similar to FinTech, has emerged as a key focus of industry and academic discussions in recent years. This dissertation examines how PropTech firms and the commercial real estate (CRE) sector generate value through digital technologies and yet often struggle to capture it. The research pursues two interconnected objectives: (1) to define PropTech and develop a typology for understanding PropTech by distinguishing it as a Vertical Technology (VT), and (2) to analyze why the value created by PropTech is often overseen or unmonetized within the CRE industry.

Objective 1 addresses the lack of clarity around what PropTech is and how it relates to broader technology development. To that end, the dissertation distinguishes General-Purpose Technologies (GPTs)—such as AI, IoT, and Blockchain—from Vertical Technologies, which are sector-specific adaptations of GPTs tailored to the needs, processes, and constraints of a particular industry. PropTech is defined as "*a vertical digital technology that integrates hardware, software, and integrated systems to meet the unique demands of the real estate sector*". This definition clarifies the technological scope of PropTech and provides a foundation for the second objective.

Objective 2 examines value capture challenges in CRE. This study employs a mixed-methods approach, conducting semi-structured interviews with stakeholders from PropTech firms, real estate companies, and industry firms in Sweden, as well as a descriptive analysis of a dataset of 2549 PropTech companies globally. Drawing on a combined path dependency and BM

framework, the findings show that while PropTech creates operational and experiential value, this value often remains uncaptured due to the industrial mechanisms in CRE. Specifically, value capture is constrained by the sector's physical legacy, outdated valuation models, and the hidden costs of building absorptive capacity and organizational learning rather than the technology itself.

Taken together, the two studies offer complementary perspectives. The first clarifies what PropTech is and how it connects to broader trajectories of technological development. The second reveals why much potential of PropTech remains unrealized in practice. By linking these insights, the thesis shows how conceptual ambiguity and institutional path dependency jointly constrain the digital transformation of the CRE sector.

**Keywords**

Property Technology; PropTech; Business Model Innovation; Valuation Model; Digital Transformation; Digitalization, Commercial Real Estate; Smart Buildings.

# II Sammanfattning

Denna avhandling undersöker hur PropTech-företag och den kommersiella fastighetssektorn (CRE) skapar värden med digitala teknologier men sedan misslyckas med att fånga detta värde. Fokus ligger på det framväxande området Property Technology (PropTech). Forskningen har två sammanlänkade fokusområden: (1) att utveckla en typologi för att förstå PropTech genom att särskilja det som en vertikal teknologi (VT), och (2) att analysera varför det värde som skapas av PropTech ofta förbises eller inte kapitaliseras inom CRE-industrin.

Första fokuset behandlar bristen på tydlighet kring vad PropTech är och hur det förhåller sig till bredare teknikutveckling. Avhandlingen skiljer därför mellan generella teknologier (General-Purpose Technologies, GPTs) – såsom AI, IoT och Blockchain – och vertikala teknologier, som är sektorsspecifika anpassningar av GPTs utformade efter en viss industris behov, processer och begränsningar. PropTech definieras som en vertikal digital teknologi som integrerar hårdvara, mjukvara och system för att möta fastighetssektorns unika krav. Denna definition klargör PropTechs teknologiska omfattning och lägger grunden för det andra målet.

Andra fokuset undersöker utmaningar kring värdefångst i CRE. Studien använder en kombinerad metodansats, inklusive semistrukturerade intervjuer med aktörer från PropTech-företag, fastighetsbolag och branschen samt en deskriptiv analys av en global databas med cirka 2549 PropTech-bolag. Med ett path dependency-perspektiv visar resultaten att även om PropTech skapar operativa, upplevelsebaserade och datadrivna värden, förblir dessa ofta orealiserade på grund av industriella mekanismer i CRE. Värdefångsten

begränsas särskilt av sektorns fysiska arv, föråldrade värderingsmodeller och de dolda kostnaderna för att bygga upp absorptionsförmåga och organisatoriskt lärande snarare än tekniken i sig.

Tillsammans erbjuder dessa två studierna kompletterande perspektiv. Första perspektivet klargör vad PropTech är och positionerar till bredare tekniska utvecklingen. Det andra perspektivet förklarar varför en stor del av PropTechs potential förblir oanvänd i praktiken. Genom att länka samman dessa insikter visar avhandlingen hur definition oklarhet och institutionell tröghet tillsammans begränsar den digitala transformationen inom den kommersiella fastighetssektorn.

**Nyckelord**

Property Technology; PropTech; Affärsmodellsinnovation; Värderingsmodell; Digital transformation; Smart Buildings.

# III Acknowledgments

This thesis marks the culmination of a fast two-year journey, and I owe my deepest gratitude to many people who have supported me along the way.

First and foremost, I would like to thank my supervisor, Bertram Steininger, for your leadership, patience, and steady encouragement throughout this process. I am equally grateful to my co-supervisor, Olli Vigren, for your endless generosity in sharing your time and knowledge — and for helping me navigate through many doubts and uncertainties.

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I would also like to thank all industry participants and interviewees who shared their time, experience, and perspectives—your insights brought this research to life and grounded it in practical applications.

To the heart of it all — my mom, Thanh Dang. Thank you for every meal, every call, and every quiet act of care that carried me here. I know that your love and sacrifices have paved every step of my journey — *con thương má*, and of course, to the rest of my family, you are my home wherever I am.

And finally, to my dearest Joel, thank you for being my steady support, my joy, and daily my reminder to stay kind and brave. I hope to make you proud.

Not a single day in the past two years has gone by without me thinking of the Palestinian people's enduring struggle, and of our shared duty to fight for their right to live in dignity, justice, and freedom.

# IV List of publications

Paper A: Dang, T. X. L., & Vigren, O. (2025). Defining Vertical Technologies – A case of Property Technology (PropTech) in the Real Estate Sector). Under review in Technovation.

Paper B: Dang, T. X. L. Value Creation Without Value Capture: The Misalignment of PropTech and Real Estate Industry. A manuscript.
- Presented at Malmö Real Estate Conference 2025, Malmö
- Presented at ERES Annual Conference 2025, Athens

# V List of abbreviations

| Acronyms | Explanation |
|---|---|
| **AI** | Artificial Intelligence |
| **B2B** | Business-to-Business |
| **BM** | Business Model |
| **CapEx** | Capital Expenditure |
| **CRE** | Commercial Real Estate |
| **FinTech** | Financial Technology |
| **GPT** | General-Purpose Technology |
| **IoT** | Internet of Things |
| **IVS** | International Valuation Standards |
| **NOI** | Net Operating Income |
| **OpEx** | Operational Expenditure |
| **PropTech** | Property Technology |
| **RICS** | Royal Institution of Chartered Surveyors |
| **SaaS** | Software as a Service |
| **VT** | Vertical Technology |

# CONTENTS

# 1 Introduction

In the real estate sector, the shift from Industry 3.0 to Industry 4.0 mirrors the move from digitization to digitalization. While earlier technologies focused on automating isolated building systems, Industry 4.0 introduces integrated, data-driven ecosystems where buildings communicate, learn, and optimize performance autonomously (Starr et al., 2021). Through PropTech innovations—including IoT, AI, and data platforms—the sector transitions from static assets to adaptive infrastructures that enhance efficiency, transparency, and sustainability (Baum & Dearsley, 2021; Lasi et al., 2014; Tagliaro et al., 2021). PropTech thus embodies the Industry 4.0 logic within the built environment, linking digital capabilities to the performance of physical assets.

## 1.1 Research background

The emergence of digital technologies has renewed long-standing debates about how innovation transforms industries. A considerable body of literature has focused on General-Purpose Technologies (GPTs), which have been defined by their pervasiveness, potential for improvement, and innovative complementarities across sectors (Bresnahan & Trajtenberg, 1995). More recently, digital technologies such as AI, IoT, and blockchain have been discussed as GPTs, given their wide-ranging potential to reshape business and industrial processes (Yang et al., 2021). While GPTs are well theorized, much less attention has been given to Vertical Technologies (VTs), and explicit definitions or analyses of VTs and their relation to GPTs remain scarce (Youtie et al., 2008), and these definitions and analyses do not cover PropTech. This

lack of conceptual clarity is striking, particularly as new vertical markets, such as FinTech, HealthTech, and PropTech, have become central to both industry and research debates.

Within this landscape, Property Technology (PropTech) has emerged as a term used to describe the integration of digital technologies into the real estate sector. Unlike FinTech, it centers on a physically asset-heavy, long-lived infrastructure (Baum, 2017; Tagliaro et al., 2021). PropTech encompasses a wide range of solutions, including smart building systems, data-driven platforms, AI-enabled analytics, and blockchain-based contracts (Saull et al., 2020; Starr et al., 2021). Industry reports and academic work highlight the potential of PropTech to improve efficiency, enhance tenant experience, and support sustainability (Baum & Dearsley, 2021; Bittini et al., 2022). At the same time, global investment in PropTech has increased sharply, with new business models introduced to the sector (KPMG, 2024; PWC, 2025).

Despite these developments, adoption in CRE has been cautious. Studies and practitioners consistently describe the real estate sector as conservative and slow to change (Baum, 2017; Gandhi et al., 2016). Research indicates that legacy systems, fragmented infrastructures, low interoperability, and cultural resistance are key barriers (Bittini et al., 2022; F. Wang, 2023). Regulatory complexity and diverging stakeholder interests further reinforce inertia. Yet, while these factors are important, they do not fully explain how or why persistence exists. The primary challenge arises from the misalignment between how the traditional real estate sector perceives value and how the digital technology sector generates it.

CRE is characterized by strong path dependency, shaped by historical decisions, institutional practices, and valuation standards that privilege stability and predictability (Mahoney, 2000; Sydow et al., 2009). Additionally, BMs in CRE are built around creating value through physical improvements, delivering it through long leases and services, and capturing it through rent levels, occupancy, net operating income (NOI), and yield (RICS, 2024; Teece, 2010; Zott & Amit, 2010). These mechanisms tend to exclude intangible, temporary, or relational forms of value. As Chesbrough (2010) has argued, technology has no inherent economic value until it is commercialized through a business model. In CRE, this often means that even when PropTech demonstrably improves operations or tenant experience, it remains invisible to

valuation practices that are anchored in the RICS Red Book and International Valuation Standards (RICS, 2024).

This misalignment between the potential of PropTech and the reasons for the persistent inertia in CRE defines the research problem of this dissertation.

## 1.2 Purpose of the thesis and research questions

The purpose of this dissertation is twofold. First, it seeks to clarify the conceptual foundations of Vertical Technologies and operationalize PropTech within this framework. Second, it examines the misalignment between PropTech value creation and CRE value capture, analysing how historical decisions constrain the translation of digital innovations into recognized financial outcomes.

These aims give rise to the following research questions (RQs):

1. What are the defining characteristics of Vertical Technologies, and how can PropTech be conceptualized within this framework?

2. What sectoral and institutional factors shape how PropTech is adopted and integrated into existing CRE business models?

3. What mechanisms within the CRE and PropTech sectors enable or hinder value creation, delivery, and capture?

4. How can different forms of PropTech value be conceptualized better to understand their compatibility with the logic of the CRE?

## 1.3 Thesis structure

The dissertation is organized into two papers.

Paper A develops a typology of GPTs and VTs, applying it to PropTech, and provides a conceptual clarification of how sector-specific technologies can be understood as part of broader technological trajectories (Bresnahan & Trajtenberg, 1995; Teece, 2018; Yang et al., 2021). This directly addresses RQ1.

Paper B examines the misalignment between the PropTech and CRE sectors. Using an explorative approach grounded in the business-model framework

and a path-dependency lens, this study identifies mechanisms that limit value capture, thereby addressing RQ2 and RQ3. The study introduces a conceptual value matrix that positions created value along the dimensions of embeddedness and transferability, illustrating which forms can be integrated into existing business models and which remain excluded, thereby addressing RQ4.

Taken together, the two studies provide complementary perspectives. The first addresses the lack of clarity around what PropTech is and how it relates to broader technology development. The second explains why much of PropTech's potential remains unrealized in practice. By connecting these insights, the thesis demonstrates how conceptual ambiguity and institutional inertia jointly shape the limits of digital transformation in CRE.

## 1.4 Declaration of contributions

This dissertation is the result of my independent research, and I am the primary author of both included papers. In Paper A, I formulated the research question, conducted a literature review, and, together with my co-supervisor, Olli Vigren, designed the typology of GPTs and VTs and co-authored the manuscript. In Paper B, I independently designed the study, collected and analysed the empirical material, and developed the value matrix. I obtained the Unissu data through the Formas project, and while my supervisors and co-supervisor provided feedback, all conceptual development, data analysis, and writing were solely my own work.

Together, the two papers form part of the Smart Built Environments project, funded by Formas – the Swedish Research Council for Sustainable Development (grant no. 2023-00095). The project investigates how digitalization transforms the built environment and develops methods for evaluating smart technologies in real estate from a sustainability perspective.

# 2 Background

## 2.1 Previous studies

Scholars have increasingly engaged with PropTech, but the literature remains fragmented. Early contributions sought to situate PropTech within the broader digital transformation of the real estate sector, emphasizing its role as part of a broader movement toward technology-driven change (Baum & Dearsley, 2021). Definitions remain contested: some works present PropTech as simply "property technology" (Viriato, 2019), while others define it in terms of platforms (Roark & Fox O'Mahony, 2023; Shaw, 2020), or the technologicalization of real estate (Tagliaro et al., 2021). (Baum, 2017) views PropTech as one aspect of a long-term digitalization process in a historically conservative industry.

Beyond definitional issues, studies have highlighted structural barriers to adoption. The real estate sector has been consistently described as slow to adopt digital innovations due to its fragmented structure (Tagliaro et al., 2024; Vigren et al., 2022), capital-intensive assets, and reliance on conservative valuation methods (Baum, 2017; Gandhi et al., 2016). Technological barriers such as legacy systems and low interoperability persist (F. Wang, 2023), while organizational obstacles include traditional workflows, limited digital literacy, and uncertainty about returns (Bittini et al., 2022; Saull et al., 2020). Regulatory and institutional complexity further exacerbates these challenges (Deipenbrock, 2020).

Parallel research on business models suggests that adoption cannot be explained solely by technical barriers. Chesbrough (2010) and Amit & Zott

(2001) emphasize the importance of business model design for realizing technological value, Vorbach et al. (2017) note that technologies are not disruptive in themselves; their impact depends on whether firms succeed in creating viable business models. In CRE, however, the institutionalized reliance on NOI, cap rates, and yields as the dominant measures of value capture (RICS, 2022, 2024) restricts recognition of new, intangible forms of value.

## 2.2 Conceptual and theoretical framework

Across the two papers, PropTech is theorized through complementary perspectives that together explain its characteristics and the fundamental barriers to its adoption. Paper A conceptualizes PropTech as a VT —a domain-specific digital technology embedded within the infrastructures, routines, logics, and norms of the real estate sector. Unlike GPTs, which diffuse widely and enable cross-sectoral transformation, vertical technologies evolve within sectoral boundaries, making their development and diffusion dependent on industry-specific compatibility. Paper B builds on this foundation by applying a business model framework to examine how this vertical embeddedness produces misalignment between PropTech suppliers and real estate firms. While PropTech creates digital and organizational forms of value, prevailing valuation and financing systems within the CRE sector continue to privilege asset-based and transferable improvements. Together, these perspectives form a coherent theoretical basis for understanding PropTech as a vertically embedded technology constrained by path-dependent industry and valuation logics.

### 2.2.1 Paper A theoretical frameworks

Paper A establishes the conceptual foundation of this dissertation by distinguishing between GPTs and VTs. GPTs are defined by their pervasiveness, capacity for continual improvement, and complementarities that enable new applications across sectors (Bresnahan & Trajtenberg, 1995; Teece, 2018), with recent examples such as AI, IoT, and blockchain extending this technological trajectory(Yang et al., 2021). While PropTech is often framed as business model or sectoral innovation, it fundamentally stems from technological developments; hence, the use of GPT and VT theory to explain how digital technologies diffuse and create value in real estate (Baum & Dearsley, 2021).

In contrast, the literature offers limited theoretical grounding for VTs. Paper A addressed it by defining VTs as industry-originated technologies and tailored general-purpose technologies, comprising hardware, software, and integrated systems designed to address the unique demands and processes of a vertical industry. This definition highlights that technologies themselves possess characteristics that determine whether they are general or vertical, depending on their degree of specialization and their embeddedness in industry-specific workflows, regulations, and practices.

Paper A positions GPTs and VTs on a continuum, rather than as a binary distinction. Technologies may develop through specialization (from GPTs to VTs) or through generalization (from VTs to GPTs). This view aligns with Teece (2018) who notes that technologies may initially emerge in narrow contexts and later extend across multiple use cases. It also draws on broader discussions in management and innovation studies, emphasizing that the characteristics of technologies evolve through contextual application (Bresnahan & Trajtenberg, 1995; Gambardella & McGahan, 2010; Pack & Saggi, 2001).

The conceptual framework emphasizes that context matters in defining and categorizing technologies. Even GPTs have industry-specific applications, while VTs are shaped by the particular demands of the sectors in which they emerge (Belderbos et al., 2012; Cardona et al., 2013; Holmström & Partanen, 2014; C.-H. Wang et al., 2015; Zhang et al., 2024). This theoretical clarification forms the basis for understanding PropTech as a case through which the relationship between technology and industry context can be examined.

Building on this conceptual foundation, Paper B examines how sectoral embeddedness influences the alignment between value creation from vertical technologies and vertical industries.

### 2.2.2 Paper B theoretical frameworks

This study combines three complementary perspectives—business model theory, property valuation theory, and path dependency theory—to explain why the CRE sector struggles to capture the value created by PropTech. The BM framework serves as the main interpretive lens, while property valuation and path dependency theories contextualize the industrial and historical structures that shape how value is defined and recognized.

Business model theory provides a foundation for understanding how organizations create, deliver, and capture value (Osterwalder & Pigneur, 2010; Teece, 2010; Chesbrough, 2010; Zott & Amit, 2010). A design of BM outlines how resources, activities, and partnerships generate customer value and how this value is monetized.

In CRE, value creation has traditionally centred on tangible, asset-based factors such as building quality, technical systems, and location, supported by operational capabilities in leasing and facility management (RICS, 2024). Increasingly, however, digital technologies—such as sensors, data analytics, and automation—are influencing how value is produced and delivered (Saiz, 2020; Tagliaro et al., 2024). These shifts challenge established value-capture mechanisms that remain rooted in the traditional valuation model (Geltner, 2007).

BM theory thus offers a framework for analysing how PropTech and CRE firms differ in their underlying value logics. It highlights the importance of aligning technological innovation with viable mechanisms for financial capture (Chesbrough, 2010; Teece, 2010). In this study, the BM framework structures the analysis of value-creation, delivery, and capture mechanisms across PropTech suppliers, clients, and stakeholders in CRE.

The concept of business model misalignment arises from the observation that technological and institutional logics in CRE operate at different speeds and under various assumptions. While PropTech firms often employ logics from the digital economy, such as service-oriented models, the RE sector continues to rely on long-term, capital-intensive structures and conservative valuation practices (Baum, 2017; Baum & Dearsley, 2021; RICS, 2024).

As Chesbrough (2010) noted, “a mediocre technology pursued within a great business model may be more valuable than a great technology exploited via a mediocre business model.” This emphasizes that successful technology adoption depends not only on technological advancements but also on the compatibility between value propositions and the BM mechanisms for value capture within a vertical industry.

In this context, misalignment refers to the limited capacity of CRE firms to integrate digital value into existing models of income and asset valuation, as well as the limited ability of PropTech suppliers to structure their offerings in ways that are financially legible within the RE logic (Wofford et al., 2020). The

BM framework is therefore used to identify how and why such incompatibilities arise across the dimensions of creation, delivery, and capture.

Valuation theory provides the financial lens through which value capture in CRE is institutionalized. Professional standards such as the RICS Red Book and International Valuation Standards (IVS).

Market value is estimated through three primary approaches—the market, income, and cost approaches—which privilege comparable, standardized, and durable attributes (Baum, 2017; Wachter, 2013). As a result, valuation practices are optimized to capture long-term, asset-embedded improvements, while digital or intangible benefits—such as data analytics or workflow optimization—remain difficult to quantify or transfer.

This theoretical framing explains how valuation routines reinforce a narrow definition of proven and sustained value, shaping both investment incentives and the perceived legitimacy of PropTech solutions in the CRE market.

To explain why valuation and business model logics persist, the study draws on the evolution of path dependency theories from David (1985), Garud et al., (2010), Mahoney (2000), Pierson (2000) and Sydow et al. (2008). Path dependency describes how historical decisions and institutional routines produce self-reinforcing mechanisms that limit future flexibility. Once a logic of value becomes dominant—such as associating financial legitimacy with physical assets—it generates increasing returns that make alternative interpretations costly to adopt.

The CRE sector exemplifies such path dependency through its reliance on long investment cycles, asset-backed financing, and conservative valuation standards. These practices have evolved into what Mahoney (2000) terms a lock-in phase, where deviations from the established model appear inefficient or risky. Later extensions of the theory by Garud et al. (2010) introduce the concept of path creation, emphasizing that breaking these trajectories requires deliberate efforts to reconfigure valuation, contracting, and data structures.

## 2.3 Research gap

Taken together, these literatures reveal two central gaps. First, there is a conceptual gap in understanding VTs. While GPTs are extensively theorized, VTs lack a clear definition and typology. PropTech has been widely adopted as

a term, yet its meaning remains ambiguous and inconsistently applied across studies (Baum, 2017; Shaw, 2020; Tagliaro et al., 2021). This limits both theoretical precision and practical utility.

Second, there is an analytical gap in explaining why PropTech adoption in CRE remains limited despite high investment flows and technological development. Prior studies identify barriers at technological, organizational, and regulatory levels (Bittini et al., 2022; Deipenbrock, 2020; Saull et al., 2020; Tagliaro et al., 2024; F. Wang, 2023), yet they often overlook how value itself is defined and captured within CRE. Using business models as an analytical framework, this study demonstrates that valuation practices in CRE—focusing on physical, proven, and lasting improvements in NOI (RICS, 2024) — systematically exclude much of the value created by PropTech from financial recognition. Moreover, the location of value, whether embedded in the organization or the asset, plays a crucial role in determining whether it becomes visible in valuation processes. A path-dependency lens is further applied to interpret how and why business and valuation models evolve, and under what conditions they might begin to recognize digital and organizational forms of value. The resulting friction between the physical and digital domains, reflected in business-model logic, has not previously been addressed in the context of real estate.

The connection between these two gaps is crucial. To understand the challenges of PropTech adoption in CRE, it is first necessary to clarify what PropTech is and its origins. Without a precise conceptualization of PropTech as a Vertical Technology—emerging from the specialization of GPTs into sector-specific solutions—it is difficult to analyze how these technologies interact with the institutional logics of traditional industries. In other words, defining PropTech is not only an academic exercise but also a prerequisite for understanding its practical implementation. By situating PropTech within the broader GPT–VT continuum in Paper A, our development of a typology and adoption of a continuum perspective highlight the often-overlooked innovation logic through which domain-specific VTs evolve toward GPTs (Dang & Vigren, 2025). We can better explain why certain forms of value creation remain uncaptured, and why the roots of these challenges lie in the specialization of general technologies into vertical contexts.

This dissertation addresses these gaps by combining conceptual clarification with empirical analysis. It first develops a typology distinguishing GPTs and

VTs, conceptualizing PropTech as a distinct VT category (RQ1). It then examines how sectoral and institutional factors shape the adoption and integration of PropTech into CRE business models (RQ2). Finally, it investigates the mechanisms that enable or hinder value creation, delivery, and capture (RQ3), and applies a path dependency lens to analyze why business-model and valuation logics affect value capture and compatibility between PropTech and CRE (RQ4).

# 3 Materials and methods

Both papers adopt mainly a qualitative and exploratory design, reflecting the emerging nature of the PropTech phenomenon. While grounded in existing literature, they combine deductive and abductive reasoning to balance theory development with empirical grounding (Flick, 2014; Gioia et al., 2013). Paper A follows a deductive and conceptual reasoning approach. It begins with a systematic literature review to identify and synthesize existing theoretical perspectives. The insights drawn from this review are then used to assess how well current theories capture the phenomenon under study. Based on the gaps identified, the paper advances a refined theoretical concept, extending existing frameworks rather than building theory from empirical data.

Paper B, in contrast, adopts an abductive and exploratory reasoning approach. It starts with empirical exploration and observation, allowing patterns to emerge inductively from the data. To structure and interpret these patterns, an initial theoretical framework is applied for coding the observations. Subsequently, a second theoretical lens is introduced to explain the underlying why behind the findings. This iterative movement between data and theory reflects an abductive process that combines exploration, interpretation, and theoretical refinement.

Together, the studies demonstrate how qualitative exploration can yield both conceptual advancements and practical insights into the unfolding of digital transformation in the real estate sector.

## 3.1 Data collection

This dissertation draws on a systematic literature review and two complementary datasets, reflecting the dual ambition of the research: to establish a clear conceptual foundation for understanding PropTech as a VT and to provide an empirical analysis of PropTech adoption within CRE.

### 3.1.1 Systematic literature review

In Paper A, the primary method was a structured literature review. The aim was to map and synthesize the fragmented body of scholarship on PropTech and, by extension, clarify the boundaries between GPTs and VTs. The objective is to provide a theory-driven explanation (Alegre et al., 2023) for PropTech as a phenomenon. The data collection process followed a transparent and replicable search strategy (Webster & Watson, 2002). Searches were conducted in the Scopus and Web of Science databases, which together provide comprehensive coverage of peer-reviewed journals relevant to management, innovation, and built environment research. Figure 1 outlines the literature search process; the search term was restricted to "PropTech" to ensure focus on articles that explicitly employed the term. This process initially yielded 80 documents. After removing duplicates and excluding non-peer-reviewed sources, the final dataset consisted of 44 academic articles published between 2019 and 2023.

The bibliographic metadata of these articles—including publication years, keywords, citations, and author affiliations—was exported into Excel and prepared for analysis with the Bibliometrix R package (Aria & Cuccurullo, 2017). To complement the bibliometric mapping, the full texts of the articles were manually read and thematically coded, with particular attention to definitions of PropTech, theoretical underpinnings, methodologies, and identified research gaps. This combination of bibliometric and qualitative data collection allowed for both breadth and depth in capturing the evolving discourse around PropTech.

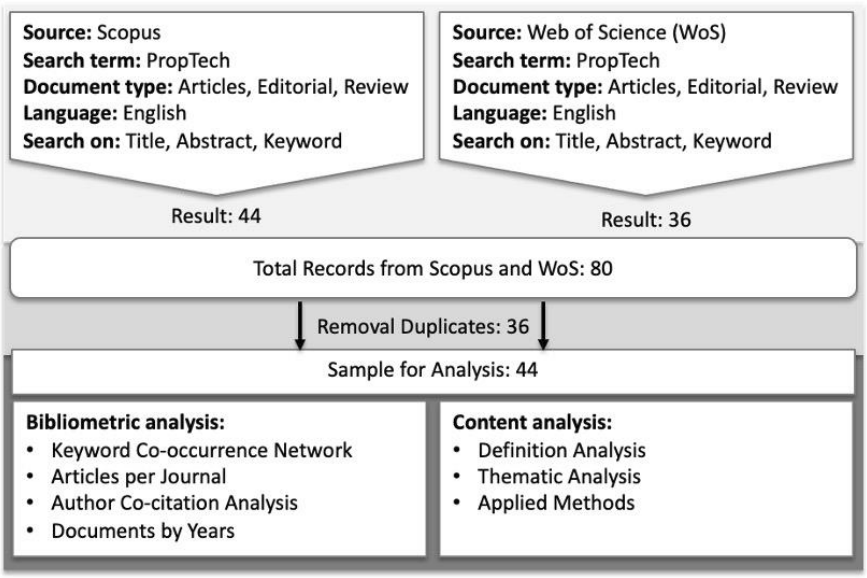


*Figure 1: Overview of the literature search and analysis process Note. Copyright 2025, Dang.*

### 3.1.2 Semi-structured interviews

In Paper B, the empirical strategy focused on understanding the misalignment between PropTech business models and CRE's value logic. Two main data sources were used. First, 11 semi-structured interviews were conducted with stakeholders across the Swedish CRE and PropTech ecosystem. These included PropTech suppliers, CRE clients and managers, as well as industry actors such as investors, appraisers, and representatives from industry associations. The interviews were designed to capture both supply- and demand-side perspectives on the integration of PropTech into real estate operations, reflecting Paper B's focus on the interaction between traditional and digital business models. Respondents were selected through purposive sampling to ensure diversity in company size, sector affiliation, and organizational role (Flick, 2014). This enabled the study to account for the heterogeneity of experiences across the industry. All interviews were recorded, transcribed, translated, and anonymized.

### 3.1.3 Archival data

Archival data was received from the Unissu database, an aggregate of data on PropTech firms globally. Specifically, the dataset on business models was utilized to illustrate the prevalence of software-as-a-service (SaaS) based

offerings in the global PropTech market. This archival data was analysed to complement the qualitative interviews, situating the empirical findings within a broader industry and international context.

## 3.2 Motivation for method choice

The choice of methods in the two papers reflects the broader logic of the dissertation: to move from conceptual clarification to empirical explanation**.**

### 3.2.1 Paper A

For Paper A, a structured literature review was essential because PropTech is a fragmented and relatively new field of research. A systematic approach was required to integrate knowledge across different disciplines, each of which engages with PropTech from various angles. As Webster & Watson (2002) argue, structured reviews are particularly valuable in emerging fields where concepts remain unclear. Similarly, Snyder (2019) it explains that integrative reviews accelerate knowledge development by combining insights from various sources. By employing a structured review method, Paper A systematically mapped the existing literature and uncovered the theoretical assumptions underlying different definitions of PropTech. This approach was guided by the aim of developing a typology of GPTs and VTs and positioning PropTech within the broader theoretical landscape.

### 3.2.2 Paper B

For Paper B, the method choice was driven by the recognition that PropTech adoption cannot be understood through quantitative data alone. The barriers and drivers of adoption are deeply embedded in organizational routines, valuation practices, and institutional logics—factors that necessitate a qualitative exploration to understand how and why they influence technology adoption. Semi-structured interviews provided the flexibility to probe these dynamics in detail, allowing respondents to articulate their interpretations of value creation, delivery, and capture. This approach aligns with calls in the business model literature to study the mechanisms through which firms define and operationalize value (Chesbrough, 2010; Osterwalder & Pigneur, 2013; Teece, 2010; Zott & Amit, 2010).

The inclusion of Unissu archival data was motivated by the need to anchor these qualitative insights in a broader empirical context. By showing that platform business models are common in the global PropTech market, the

analysis supported the interviews and strengthened the argument about business model misalignment. Combining global data with local insights also deepened the analysis by connecting everyday organizational practices with larger technological trends, in line with a path dependency perspective.

## 3.3 Analytical methods

The analytical procedures in the two papers were designed to ensure systematic, rigorous, and transparent interpretation of the data (Yanoff, 2022).

### 3.3.1 Bibliometric analysis

In Paper A**,** the analysis proceeded in two stages. First, bibliometric analysis was conducted using Bibliometrix and its web interface, Biblioshiny (Aria & Cuccurullo, 2017). This enabled the visualization of keyword co-occurrence networks, co-citation patterns, and publication trends, providing an overview of how PropTech research has evolved and its distribution across journals and disciplines. Second, the articles were read in full and coded systematically. Definitions of PropTech were extracted, classified as lexical or stipulative, and compared for their underlying assumptions. In addition, theoretical frameworks, methodologies, and research gaps were categorized into five areas: Technology, Business, Socio-Ethics, Legal, and Behaviour. This dual analytical strategy enabled Paper A to transition from descriptive mapping to conceptual synthesis, culminating in the development of a typology that distinguishes GPTs and VTs.

### 3.3.2 Open, pattern coding, and Gioia method

The analysis followed a three-stage process combining inductive discovery with deductive validation. In Stage 1, an exploratory coding cycle using a pattern-identification approach (Miles et al., 2014) captured the full range of interview insights. Each data segment—ranging from short phrases to whole paragraphs—was assigned a descriptive or evaluative code. A second cycle condensed these into broader explanatory patterns reflecting key variables across stakeholder groups, establishing the empirical foundation for the first-order structure of the subsequent Gioia analysis (Gioia et al., 2013).

In Stage 2, the data were transferred to Atlas.ti, where the Gioia framework was operationalized through a hierarchical structure linking themes, mechanisms, and BM dimensions of value creation, delivery, and capture, see Figure 2. Each quotation was re-coded and linked to stakeholder metadata

(PropTech supplier, real-estate client, or consultant). Overlapping themes were merged, and mechanisms refined to maintain analytical precision. This stage yielded 278 coded quotations, 39 mechanisms, and nine themes, systematically organized within the BM framework and categorized according to the first- and second-order levels of the Gioia framework.

Stage 3 involved a meta-level synthesis in Atlas.ti using co-occurrence analysis to visualize overlapping mechanisms as interpretive cues rather than statistical measures. Stakeholder metadata further revealed variation across actor groups and value stages. Through iterative reflection, co-occurring and theoretically aligned mechanisms were consolidated into three aggregate dimensions—value-capture constraints, business-model misalignment, and hidden organizational cost—integrating data-driven insights with theoretical reasoning and forming the bridge to the path-dependency interpretation.

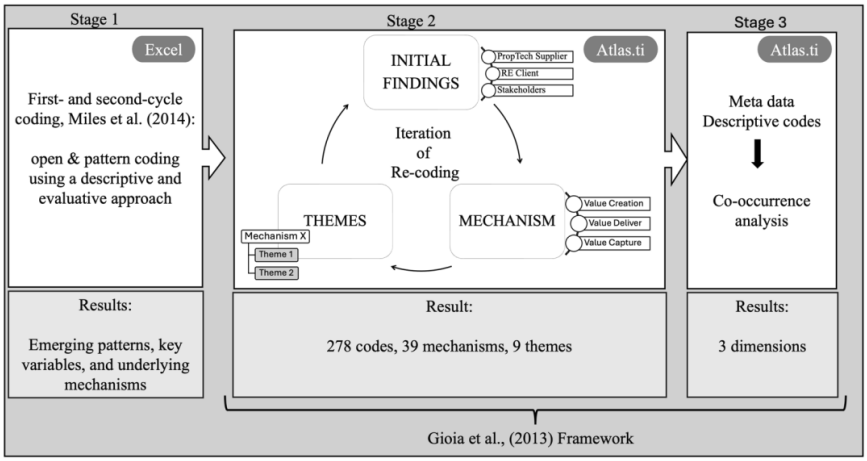


Figure 2. *Stepwise Data Analysis Process. Note. Copyright 2025, Dang.*

### 3.3.3 Archival data analysis

The archival data from Unissu was analysed separately to identify the distribution of business models among PropTech firms, with particular attention to the dominance of SaaS. This descriptive analysis provided empirical support for the patterns identified in the interview data.

Taken together, the analytical methods of the two papers reflect a consistent logic: Paper A provides a conceptual synthesis through structured review and bibliometric mapping, while Paper B operationalizes these insights in an

empirical setting through qualitative coding and the construction of an analytical framework.

## 3.4 Ethical considerations

Both studies adhered to the principles of ethical research. In Paper A, all data were derived from published academic articles indexed in Scopus and Web of Science. No personal or sensitive data was involved. The integrity of the review was ensured by transparent reporting of search strategies, inclusion criteria, and coding procedures (Vetenskapsrådet, 2024). In Paper B, ethical considerations were more central due to the collection of primary interview data. Participants were recruited voluntarily and provided informed consent. Interviews were anonymized during transcription, and any identifying information about individuals or companies was removed. Respondents' perspectives are presented in aggregate form to protect confidentiality while retaining the richness of the data.

# 4 Results

This section will summarize Paper A and Paper B, focusing on their background, findings, and contributions. The summary will also address our four research questions. Table 1 presents an overview of the papers, the theories they adapt, the research questions they address, and their contributions.

| Article | Paper A | Paper B |
|---|---|---|
| **Title** | Classifying vertical and general-purpose technologies (GPT) – A case of property technology | Value creation without value capture: the misalignment of property technology and real estate industry |
| **Addressed research question(s)** | RQ1: What are the defining characteristics of Vertical Technologies, and how can PropTech be conceptualized within this framework? | RQ2.What sectoral and institutional factors shape how PropTech is adopted and integrated into existing CRE business models? |
| | | RQ3.What mechanisms within the CRE and PropTech sectors enable or hinder value creation, delivery, and capture? |
| | | RQ4.How can different forms of PropTech value be conceptualized better to understand their compatibility with the logic of the CRE? |
| **Theoretical lens/ framework** | • General-purpose technology theory | • Business Model framework.<br>• Path Dependency Theory |
| **Contributions** | Provides conceptual and definitional clarity of VTs; positions PropTech as a distinct vertical category; introduces typology of GPT and VT. | Explains institutional and valuation barriers to PropTech adoption; connects organizational and asset-level value; extends path-dependency to digital–physical interaction. This could be used as blueprint to understand friction between traditional sector and tech-sector. |

*Table 1. Overview of theories and contributions of Paper A and Paper B.*

## 4.1 Summary of Paper A

### 4.1.1 Background

Paper A addresses the conceptual ambiguity surrounding VTs and their relationship to GPTs. While GPTs—such as electricity, semiconductors, and

artificial intelligence—are well-theorized as transformative technologies with broad spillover effects (Bresnahan & Trajtenberg, 1995; Yang et al., 2021), VTs remain underdefined. This gap is particularly visible in PropTech, where digitalization of the built environment is accelerating without a shared conceptual foundation. To answer RQ1 – What are the defining characteristics of Vertical Technologies, and how can PropTech be conceptualized within this framework? – The paper develops a typology clarifying how domain-specific technologies differ from and relate to GPTs.

### 4.1.2 Results

The structured review yielded several key results that reveal the state of PropTech research as both fragmented and conceptually unsettled; publications rise sharply after 2019 but are dispersed across many outlets with weak cross-linkages. The bibliometric mapping demonstrated that while publications on PropTech have increased rapidly since 2019, the literature remains dispersed across journals and disciplines, with limited cross-referencing between clusters. Figure 3 shows that article co-citation analysis reveals several small communities rather than a single core, underscoring conceptual dispersion. This fragmentation suggests that PropTech research has yet to establish a unified theoretical foundation.

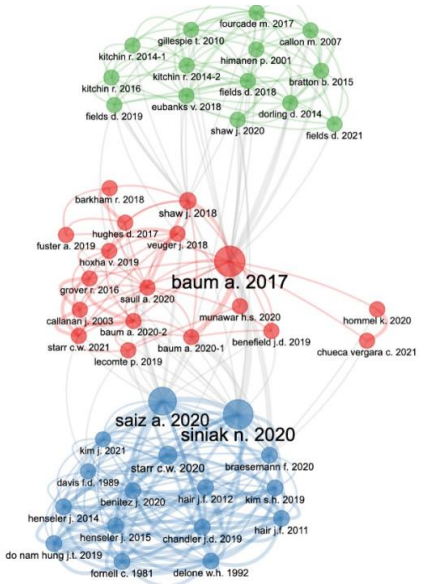


*Figure 3: Article co-citation analysis (Isolated nodes are omitted; Walktrap clustering algorithm). Note. Copyright 2025, Dang and Vigren*

**RQ1: What is PropTech?**

This pattern suggests that the definitional ambiguity is not accidental but rather reflects a deeper theoretical uncertainty about how digital transformation unfolds in traditional industries. The discussion interprets this ambiguity as evidence that PropTech should be theorized not as a GPT itself but as a VT. A VT can be defined as a specialization of a General-Purpose Technology into a sectoral context, see Figure 4, where hardware, software, and integrated systems are tailored to the operational processes, institutional logics, and regulatory structures of a particular industry. Viewing PropTech as a VT explains why it simultaneously inherits the transformative potential of GPTs (Bresnahan & Trajtenberg, 1995; Teece, 2018) and faces strong contextual constraints shaped by real estate established practices (Baum, 2017; RICS, 2022).

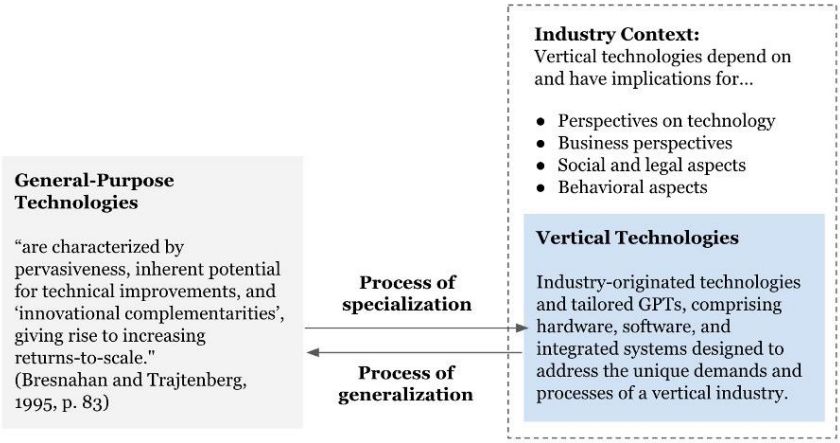


*Figure 4: Vertical technologies and General-Purpose Technologies. Note. Copyright 2025 by Dang & Vigren.*

On this basis, we operationalize the logic of VTs in PropTech, which can be defined as a vertical digital technology that integrates hardware, software, and data-driven systems to address the specific demands and constraints of the real estate sector, including development, operations, and transactions. This definition captures the dual nature of PropTech—as both an extension of general digital technologies (e.g., AI, IoT, blockchain) and a technology embedded in the unique workflows of the real estate sector.

The results identify PropTech as a Vertical Technology (VT) and conceptualize its position along a continuum from General-Purpose to Vertical Technologies, as shown in Figure 5. The figure illustrates how technologies evolve from

Emerging and Applied GPTs, which are broad and cross-sectoral, toward Tailored and Industry-Originated VTs, which are designed for specific sectoral needs. Within this continuum, PropTech is situated toward the vertical end, reflecting how digital technologies (e.g., AI, IoT, blockchain) are customized to meet the unique institutional, regulatory, and operational conditions of the real estate sector. This positioning explains why PropTech's innovation and value capture are inherently context dependent.

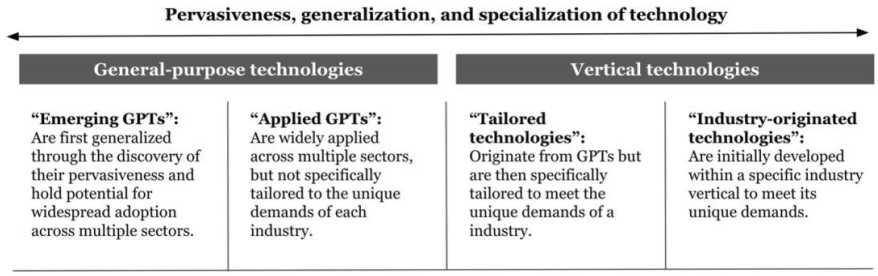


*Figure 5: Typology of general-purpose and vertical technologies. Note. Copyright 2025 by Dang & Vigren.*

### 4.1.3 Contribution

The contribution of Paper A is the definition of VT and PropTech, which defines "PropTech as a *vertical digital technology* integrating hardware, software, and data-driven systems to meet the specific demands of real estate—development, operations, and transactions" Dang T.X.L and Vigren( 2025). Justification lies in arguing that treating PropTech as a VT resolves part of this conceptual tension. By situating PropTech as a vertical specialization of GPTs into the real estate industry, the paper highlights the importance of sectoral embeddedness. Technologies cannot be understood only by their technical features; their meaning and impact are shaped by the industries into which they are embedded. This insight clarifies why PropTech remains simultaneously celebrated and constrained: it is not a universal technology, but a sector-specific adaptation shaped by the historical, institutional, and organizational features of the real estate sector. As illustrated in Figure 5, the typology positions PropTech within the continuum between GPTs and VTs, capturing the evolution of technologies from general digital infrastructures to domain-embedded applications.

## 4.2 Summary of Paper B

Table 2 summarizes the conceptual structure of Paper B, which addresses RQ2, RQ3, and RQ4. Using the business model framework, the study examines how sectoral and institutional factors influence the adoption and integration of PropTech in CRE. It identifies a business-model compatibility gap arising from misaligned value logics and reinforced by hidden organizational costs. The analysis of mechanisms that enable or hinder value creation, delivery, and capture reveals the tension between organizational and asset-embedded value. Applying a path-dependency lens, the study explains the persistence of these frictions and proposes a blueprint for conceptualizing PropTech value that bridges the physical and digital domains.

| Level | Concept/result | Function in Paper |
|---|---|---|
| **Phenomenon** | PropTech adoption in CRE | What is being studied |
| **Analytical lens** | Business model mechanisms (creation, delivery, capture) | Organize empirical coding |
| **Emergent constructs** | Organizational vs. asset-embedded value | Explain value location |
| **Core finding** | BM value compatibility gap | Explain adoption friction |
| **Supporting construct** | Hidden organizational cost | Explain under-recognition of digital gains |
| **Interpretive lens** | Path dependency | Explain persistence of the gap |
| **Theoretical contribution** | Blueprint for bridging physical & digital value | Extend path dependency theory |

*Table 1: Overview of different concepts/results and their functioning for Paper B.*

### 4.2.1 Background

Although PropTech is widely recognized as a catalyst for efficiency and sustainability in CRE, adoption remains limited. Prior research explains this through technological, regulatory, and cultural barriers; however, less attention has been paid to how value is defined and captured across different industries and why the barriers exist. This study addresses that gap by examining business model compatibility between PropTech firms and CRE

actors. It argues that the key barrier is strategic—PropTech generates organizational-embedded digital value, while CRE valuation practices recognize only asset-embedded, transferable value. Understanding this misalignment is essential for explaining why operational improvements fail to translate into asset-level gains.

#### 4.2.2 Result

**RQ3.What mechanisms within the CRE and PropTech sectors enable or hinder value creation, delivery, and capture?**

The archival data confirm that SaaS dominates as the primary BM offered to the existing building stock. This result provides an empirical foundation for the subsequent content analysis, supporting the assumption that PropTech primarily operates through subscription-based and scalable service models. The first-order Gioia analysis identified nine mechanisms: innovation process, domain knowledge, digital capability, technology, business interaction structure, pricing strategy, financial strategy, scalability, and valuation. Using the BM framework as an analytical lens, these mechanisms were aggregated into three conceptual dimensions that explain value location, adoption direction, and the under-recognition of digital gains.

**RQ4.How can different forms of PropTech value be conceptualized better to understand their compatibility with the logic of the CRE?**

Content analysis of the aggregate dimensions reveals three interrelated patterns shaping the compatibility gap between PropTech and the real estate sector

(i) Valuation recognition remains strongly oriented toward improvements that are enduring, asset-embedded, and standardized. In practice, this means that only technologies demonstrably "resident in the building" and capable of producing lasting, auditable effects are recognized in appraisal models. Temporary or organization-dependent gains—such as workflow efficiencies, digital interfaces, or cloud-based systems—are systematically excluded from asset valuation, even when they generate measurable operational benefits.
(ii) Clients and stakeholders dominate the discourse surrounding value capture and are primarily framed through financial and accounting categories such as CapEx/OpEx classification, lifecycle budgeting, and balance-sheet treatment. This framing exposes how deeply valuation logics are tied to traditional financial structures rather than functional outcomes. The decision to categorize an investment as capital or operational expenditure thus becomes

central to whether digital value can be monetized or capitalized over time. (iii) The hidden actual cost of PropTech adoption is revealed as organizational transformation rather than pure technology spending. The largest investments occur in competence building, process redesign, and data infrastructure—efforts that enable digitalization but remain internal to the organization. Because these expenditures are booked as operating costs, they do not translate into asset-level value and instead remain embedded within the organization. This accounting treatment reinforces the misalignment between how digital value is created and how it is captured in CRE—booked as OpEx and retained within the organization.

**RQ2.What sectoral and institutional factors shape how PropTech is adopted and integrated into existing CRE business models?**

To explain why these mechanisms persist, the study integrates organizational, institutional, and temporal perspectives from path dependency theory. The resulting 2×2 conceptual matrix (see Figure 6) positions value along two dimensions: embeddedness—whether value resides within the organization or the asset—and transferability—whether value can be realized or retained at transaction. This framework visualizes how CRE path-dependent logic privileges value that is both asset-embedded and transferable, thereby marginalizing digital or organizational value that is less visible in market transactions.

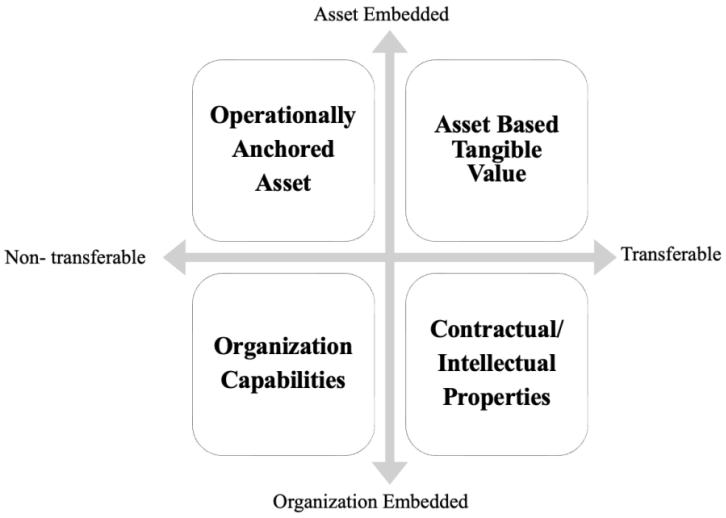


*Figure 6: Conceptual framework illustrating how value components in CRE vary by their locus of value and transferability at the transaction. Note. Copyright 2025, Dang*

Figure 6 illustrates four ideal types of value in CRE. The upper-right quadrant represents asset-based tangible value, such as certified building upgrades or physical retrofits, which are easily capitalized and transferred through valuation. The upper-left quadrant—operationally anchored assets—captures physical improvements tied to use rather than ownership, such as customized installations, which add functional value but depreciate when transferred. The lower-right quadrant reflects contractual or intellectual properties, including data-driven services or long-term digital contracts, which can, in principle, be transferred if legally codified. Finally, the lower-left quadrant—organizational capabilities—represents the most challenging form of value to recognize process efficiency, data integration, or digital expertise embedded in the firm's routines rather than in an asset.

The CRE sector's preference for "sustainable and proven value" reflects what can be described as path-dependent physicality: a historically reinforced association between tangible improvements and financial trustworthiness. This logic constrains the recognition of dynamic, digitally enabled value that resides within organizations, rather than in assets. Consequently, PropTech innovations that enhance efficiency, data quality, or decision-making often fail to produce transferable value at the transaction. The temporal dimension of path dependency compounds this effect: CRE operates on long investment cycles and conservative valuation standards that reward durability and comparability. Organizationally embedded PropTech value, unless made transferable—through data standardization, contractual design, or valuation reform—thus depreciates both financially and institutionally when ownership or tenancy changes.

#### 4.2.3 Contribution

This paper contributes to the literature by reframing PropTech adoption in CRE as a problem of value localization and transferability. By integrating BM theory with path dependency, it explains why digital value—though real—often remains unrecognized in asset valuation. The proposed 2×2 conceptual matrix positions value by its physicality and transferability, revealing how organizationally embedded gains from PropTech contrast with valuation models focused on enduring, asset-embedded improvements. Empirically, the study shows that SaaS BM, the CapEx/OpEx divide, and differing logics of scalability between suppliers and clients reinforce this misalignment. The contribution lies in demonstrating that value capture failure stems not from

the absence of value, but from institutionalized valuation and financial structures that hinder its recognition.

# 5 Conclusions

Together, the two studies address PropTech from definition to application. Paper A positioned PropTech within the framework of Vertical and General-Purpose Technologies (VTs and GPTs), defining it as a category of industry-originated and tailored technologies developed to meet the specific demands of the real-estate sector. This conceptual clarification established PropTech as a technological category rather than a firm type or socio-economic movement, emphasizing its contextual and sector-specific character.

Paper B built upon this conceptual foundation to explore why PropTech adoption in CRE remains limited despite clear technological potential. Using a BM framework and a path-dependency lens, it identified how institutionalized valuation routines and long investment cycles recognize only asset-embedded, standardized, and proven value while overlooking organizationally embedded, digital value. The findings revealed a compatibility gap between PropTech's business logic and CRE's valuation systems, explaining why technological gains often fail to translate into measurable financial outcomes.

Together, the papers move from what PropTech is to how it functions—and fails to capture value—within its host sector. They connect conceptual theorization with empirical mechanisms, demonstrating that successful technology integration in CRE requires both definitional clarity (Paper A) and business model alignment (Paper B).

## 5.1 Contribution

The two papers jointly contribute to the emerging PropTech literature and to broader debates on technological innovation in traditional sectors.

### 5.1.1 Conceptual contribution

Paper A develops a definition and typology of PropTech as a Vertical Technology, extending GPT/VT theory by highlighting that technologies evolve bidirectionally, generalizing from specific domains or specializing from generic applications.

### 5.1.2 Empirical and theoretical contributions

Paper B operationalizes this conceptualization within CRE, utilizing the embeddedness–transferability matrix to explain the interaction between digital and physical value. It reframes PropTech adoption not as a matter of technical readiness but as a problem of value localization and transferability.

Combined, the papers link macro-level technological theory with micro-level business-model mechanisms, offering a framework for analysing how sectoral characteristics shape the trajectory of digital transformation.

In relation to existing literature (e.g., Baum 2020; Tagliaro et al. 2024; Vigren et al. 2022), the thesis expands understanding of PropTech from a descriptive phenomenon to an analytical construct with explanatory power for why and how digitalization unfolds unevenly across verticals.

## 5.2 Limitation

Both studies share limitations related to scope and data. The literature review in Paper A focused solely on peer-reviewed sources that explicitly used the term *PropTech*, omitting related but adjacent research strands, such as ConTech or Smart-City technologies. Paper B relied mainly on qualitative interviews within the Swedish B2B context, and a global dataset (Unissu) weighted toward U.S. firms, which may affect its representativeness. The focus on the management phase of CRE excludes the development and transaction stages, where other mechanisms may be in operation.

## 5.3 Implications and future research

Managerially, the studies show that PropTech value must be designed to be captured. CRE firms need contracting and valuation practices that bridge

organizational and asset-level value—through KPI-linked service clauses, hybrid CapEx/OpEx models, and accounting mechanisms that recognize digital contributions to NOI. Policymakers and professional bodies should consider updating valuation standards to include operational and data-driven improvements.

Future research should extend this integrated framework to other asset-heavy verticals—such as infrastructure, energy, and healthcare—to explore how digital and physical paths co-evolve. Longitudinal studies could trace how Vertical Technologies evolve into more general-purpose forms, examining feedback between specialization and generalization over time. Moreover, further inquiry is needed into how institutional adaptation—in valuation, regulation, and finance—enables the transfer and persistence of digital value across ownership cycles.

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# 7 Appended papers

Paper A

Paper B