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HUMAN FACTORS IN PROPTECH ADOPTION: PROFESSIONAL READINESS AND ORGANISATIONAL CHALLENGES IN BALTIC REAL ESTATE

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Abstract: *This study examines the human and organisational factors influencing the adoption of property technology (PropTech) among real estate professionals in the Baltic States (Lithuania, Latvia and Estonia). Adopting a Human-Technology-Organisation (HTO) perspective, the research explores how professionals integrate digital tools into their daily work. Data collected via a questionnaire survey of 20 Baltic real estate executives was analysed using the Relative Importance Index (RII). The findings reveal that PropTech is primarily utilised for people-intensive functions, such as marketing, customer relations and contract administration. It serves to augment human interaction rather than replace it. The most significant barriers to adoption were found to be primarily human- and knowledge-based, including insufficient investment capital, legal ambiguity and, critically, low PropTech knowledge among employees. This knowledge deficit creates uncertainty among staff regarding the proper use of digital tools. Theoretically, the study emphasises that adoption of advanced technologies is strongly moderated by personnel availability, professional knowledge and learning processes rather than technology level itself. In practice, the results highlight the urgent need for real estate industry HR and training departments to address this knowledge gap through targeted training, knowledge transfer and dissemination of best practice. Furthermore, policy should prioritise aligning PropTech investment with human capital development.*

Keywords: *PropTech, human-technology interaction, technology adoption, professional competence, organisational change, real estate*.

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INTRODUCTION

The pervasive presence of technology permeates every facet of modern life, including the real estate sector, which is undergoing a profound transformation. Core activities such as property analysis, transactions (buying and renting) and facility management have been greatly improved by digital developments. Furthermore, these technologies effectively mitigate traditional barriers and neutralise challenges historically imposed by the physical location and distance of real assets. The digital transformation of the real estate sector has advanced significantly in recent decades as emerging technologies have continuously altered conventional methodologies (Le et al., 2019; Al-haimi et al., 2025). While technology has been used in real estate for many years, investment in innovative property technologies, or PropTech, has accelerated tremendously in recent years, driving rapid development in the sector (CRETI, 2024). This technological evolution is closely linked to changes in professional behaviour, cognitive demands, and organisational culture. Understanding how real estate professionals and consumers adapt to, and are affected by, these tools is essential for fostering a human-centred technological world. This research therefore provides vital empirical data on the social, organisational, and psychological challenges that accompany the adoption of sophisticated ICT in a professional setting.

PropTech is just one aspect of the real estate industry's broader digital transformation. It encompasses technological and mental shifts within the industry, as well as client attitudes, movements, and transactions related to buildings and cities (El Jaouhari et al., 2025). PropTech encompasses a wide range of technological applications that serve as the foundation for digital transformation. It includes building technology, such as smart buildings and Internet of Things (IoT)-based sensors; smart city development; building information modelling (BIM); augmented reality; artificial intelligence; and data analytics. It also includes critical enabling technologies, such as digital twins, blockchain, and asset tokenisation; as well as specialised climate tech (ESG) solutions (El Jaouhari et al., 2025; Tagliaro et al., 2025a, 2025b). This ecosystem of PropTech solutions is essential for driving efficiency, automation, and value creation across the global real estate market.

The current phase of technological evolution, often referred to as PropTech 4.0, has already proven to be a transformative force in the real estate industry. By leveraging advanced technologies such as AI, digital twins and tokenisation, it improves efficiency, transparency and sustainability (ESCP Business School, 2024; Kassner et al., 2023; Starr et al., 2021). This shift redefines the role of real estate professionals, requiring them to master complex digital tools and collaborate more closely with automated systems. This redefines their core professional competencies. Building on this, the emerging concept of PropTech 5.0 will incorporate cutting-edge technologies, emphasising enhanced human–machine interaction, continued efficiency gains and a decisive focus on reducing the environmental impact of the real estate industry (Chen et al., 2025; Tagliaro et al., 2025b). This rapid evolution highlights the importance of continuous adoption and strategic investment to remain competitive in an increasingly digital global market.

The widespread adoption of the Internet of Things (IoT) has significantly increased the global carbon footprint, making energy-efficient solutions and Green IoT (G-IoT) necessary. However, implementing G-IoT poses technological challenges relating to software, hardware, architecture and communication networks that require further analysis (Alsharif et al., 2023).

This is particularly important since smart buildings rely heavily on Information and Communication Technologies (ICT) to automate processes and control operations in an allegedly sustainable manner (Liu & Mishra, 2022). This reliance coincides with the growing demand for smart buildings in the real estate market. These buildings have interactive features that respond dynamically to users' needs and changing conditions, whether external (e.g., climate and grid prices) or internal (e.g., occupants' requirements) (Al Dakheel et al., 2020). Furthermore, smart technology, particularly digital twin modelling, can significantly improve occupant comfort and productivity while using less energy than conventional buildings (Liu et al., 2025; Plohl & Čuš Babič, 2024). Crucially, these systems enhance the human experience within the built environment by providing a better quality of life for users through the creation of personalised and adaptive indoor climates. The Internet of Things (IoT) is fundamentally changing how environments, cities, and buildings are managed. The potential impact of IoT applications extends beyond the systems and devices with which users interact (Le et al., 2019). These applications can also track and improve employee and occupant health and well-being (Semeraro et al., 2025; Venkateswarlu & Sathiyamoorthy, 2025). Despite the exponential growth of Internet of Things (IoT) deployment, developing smart, user-oriented applications requires integrating IoT technology with data from the built environment. This necessitates the convergence of diverse building disciplines and systems. This complex technological requirement demonstrates that a thorough evaluation of PropTech adoption must consider economic efficiency and environmental sustainability.

Big data is fundamentally revolutionising consumer and real estate analysis. Artificial Intelligence (AI) applications are critical for enabling this transformation, helping companies sift through large amounts of data to gain valuable insights about consumers, risk, profit, and performance (Jamaludin & Mustafa, 2025). AI's primary application in the real estate industry extends beyond passive information management; it serves as the core engine for prescriptive big data analytics. AI tools continuously collect, aggregate, and analyse extensive property, market, and portfolio data. This includes structured data as well as unstructured sources such as social sentiment and online reviews. Processing this vast and diverse dataset enables the behavioural modelling and automated analysis required to convert raw data into actionable real estate strategies (DeLisle et al., 2020). Consequently, AI technology reduces the cognitive load associated with data processing, enabling real estate professionals to dedicate their expertise to complex negotiations and client relationship management. However, AI technology is shifting the industry's focus from tracking past events to proactively managing future outcomes and adding value throughout the entire property lifecycle. This advanced intelligence, powered by deep learning and vast datasets, is driving significant change. AI enables superior prescriptive analytics, which directly enhances market trend forecasting by significantly improving accuracy compared to traditional methods (Kandi Pati, 2025). This is particularly important given that traditional transaction-based data can lag behind actual market developments by several quarters, potentially distorting price indices and market assessments (Hill et al., 2024; Kapingura et al., 2024). This increased precision allows real estate professionals to anticipate market changes and make informed decisions proactively.

Compared to traditional methods, AI methodologies, including machine learning, significantly improve the accuracy of market trend forecasting. These models improve prediction accuracy by efficiently processing large amounts of data and identifying patterns that humans might overlook (Fourkiotis & Tsadiras, 2023). Advanced statistical techniques

such as Bayesian Model Averaging further enhance the identification of key determinants driving housing market dynamics (Trojanek et al., 2023; Mukayev et al., 2022). AI also improves operational management through automation. Furthermore, integrating AI (deep learning) with BIM-enabled AR is essential for improving model registration, which is crucial for utilising AR in maintenance operations and optimizing building management. This proactive management uses real-time data from IoT sensors to predict equipment failures, optimize maintenance schedules, and increase equipment lifespan, transitioning to a predictive maintenance model (Ashour & Yan, 2020; Das et al., 2025). This approach drives operational efficiency and cost reduction while ensuring higher reliability and performance. Proactive management also extends to energy efficiency and sustainable operations. In smart buildings, AI systems continuously adjust consumption to meet sustainability goals (Emedo et al., 2025). Finally, AI is restructuring client interfaces and transactional governance. AI optimizes client interaction through personalised, continuous responsiveness. Its integration into smart contracts ensures greater accuracy and transparency in real estate transactions (Zhao et al., 2024). Ultimately, AI provides real estate professionals and investors with valuable insights to guide strategic decisions and optimize investment strategies (Seagraves, 2024). The synergy between the Internet of Things (IoT), big data, and AI is radically reshaping the strategic landscape of real estate. This integrated framework, fuelled by real-time data from smart buildings and refined by advanced AI algorithms, improves operational efficiency, automates decision-making processes, and creates powerful predictive models. These models significantly impact and optimize marketing, sales, customer service, and consumer behaviour across all portfolios, establishing data as a strategic asset for gaining a competitive edge.

Despite the significant benefits of integrating AI into the real estate sector, three primary concerns arise. Firstly, data privacy is paramount because AI systems require large amounts of personal and proprietary data in order to learn. This necessitates the implementation of robust security measures (Rojek et al., 2025; Seagraves, 2024; Szumilo & Wiegelmann, 2024). Secondly, the integration of AI technology raises ethical concerns about the potential for algorithmic bias. AI models that are trained using historical data which reflects existing disparities can perpetuate those biases in their predictions. This can lead to unfair outcomes and necessitate the implementation of robust ethical frameworks (Kalogiannidis et al., 2024; Perry et al., 2023). These issues undermine human trust in the technology directly and challenge the principles of fairness and equity in market access and professional opportunities. Thirdly, automation has the potential to displace jobs, particularly those involving routine paperwork and compliance. Businesses must therefore develop strategies to upskill their existing workforce and navigate this complex technological transition effectively (Seagraves, 2024; Siderska et al., 2023; Wach et al., 2023). Addressing these challenges requires stringent governance models and a commitment to the responsible and ethical deployment of AI across the industry.

Building Information Modelling (BIM) is a vital tool in the real estate sector, improving construction project management, enhancing performance, and providing consistent data for strategic asset management throughout a building's lifecycle (Dixit et al., 2019; Sarvari et al., 2020). Due to high demands for quality, efficiency, and sustainability, BIM has become essential for designing and assessing green buildings (Fonseca Arenas & Shafique, 2023; Tran et al., 2024; Waqar et al., 2023). In this context, BIM has become essential for improving efficiency and ensuring high-quality construction (Sarvari et al., 2020; Tran et al., 2024). It

provides significant benefits in designing and assessing the sustainability of buildings. Furthermore, BIM is used to create comprehensive digital repositories of building components that facilitate the management of buildings and facilities throughout their lifecycle (Dixit et al., 2019). As BIM technology continues to evolve and transform the construction and real estate industries, it is primarily integrating with immersive visualisation technologies to unlock new levels of access and collaboration.

Specifically, the integration of BIM with technologies like augmented reality (AR) creates new functions by overlaying digital models onto real-world environments. AR technology overlays digital models onto real-world environments, offering a realistic and immersive view of proposed designs. The ability to transfer virtual building designs into the physical environment significantly improves the architectural design process by enhancing perception, communication, and collaboration among stakeholders (Khan & Panuwatwanich, 2021). Moreover, the integrated BIM and mobile augmented reality (MAR) environment provides facility managers with real-time, on-site access to essential BIM data. This access is crucial for tasks such as structure assembly and facility management (Khan & Panuwatwanich, 2021; Liao & Luo, 2025), and it helps managers make informed decisions quickly and efficiently. Systems that integrate BIM data into mobile augmented reality (AR) environments provide facility managers with interactive tools for maintenance and operations. Real-world applications have demonstrated the feasibility and significant advantages of this integration, enhancing the effectiveness, efficiency and precision of construction and facility management tasks (Dahbi et al., 2022; Khan et al., 2024). This integration transforms the cognitive work of facility managers by providing real-time data visualisation and reducing human error, thereby improving professional decision-making on-site.

However, the BIM-driven transformation extends beyond AR, encompassing the broader integration of AR and VR. This combination provides stakeholders with powerful, immersive digital tools throughout the property lifecycle. Notably, it allows customers to virtually explore properties for sale or rent, saving them significant time and money (Anderies et al., 2023; Deep et al., 2025; Pralhad et al., 2021). Thus, the sophisticated integration of BIM, AR, and VR demonstrates PropTech's vast potential to transform traditional industry workflows and increase stakeholder value.

Blockchain technology is poised to revolutionise the real estate sector by establishing a foundation of efficiency, transparency, and trust. As a digitized, distributed ledger that immutably records and shares information, blockchain enables profound effects across the industry, transforming core operations such as property transactions, due diligence, and secure title management (Veuger, 2018). This foundational technology empowers the commercial real estate (CRE) industry to improve the transparency and efficiency of information sharing (Deloitte Center for Financial Services, 2017), possessing the potential for the creation of new business models and services. Noteworthy use-cases include smart contracts that can execute conditional transaction clauses and asset tokenisation, whereby property is broken down into digital shares. This significantly improves market liquidity and accessibility for smaller investors (Saari et al., 2022; Paavo et al., 2025). Consequently, blockchain acts as vital infrastructure within PropTech, ensuring that the data used by AI and IoT applications is verifiable and thereby bolstering the overall reliability of the system. This holistic ecosystem, which encompasses BIM/AR/VR visualisation, AI-driven analytics and blockchain-secured transactions, enables all stakeholders,

including owners, investors and service providers, to collaborate and derive greater value, thus demonstrating the full transformative potential of PropTech.

PropTech is driving widespread changes across the real estate market, fundamentally altering how owners, investors and developers perceive real estate as an asset class (Brown, 2018). This transformation is intrinsically linked to financial technology (FinTech), given that the real estate sector is one of those most profoundly impacted by FinTech innovations. FinTech companies are developing new solutions that are advancing financial services and the real estate industries, thereby fundamentally altering real estate transactions. This synergy is primarily evident in crowdfunding, mortgages, lending, leasing, and sophisticated data and analytics platforms (Mattarocci & Scimone, 2022; Saiz, 2020). Overall, the integration of financial technology and real estate innovation is restructuring traditional capital allocation and transactional workflows.

Real estate entities must adopt a proactive strategy to manage the ongoing digital transformation of their financial and operational workflows. To ensure sustainable growth and long-term profitability, contemporary companies should prioritize the key areas identified in recent research (Ciaramella & Dall'Orso, 2021; Clayton et al., 2019; Kassner et al., 2023; Phan & Boge, 2023; Saull et al., 2020; Souza et al., 2021). These priorities include: (1) cultivating agility and innovation for a competitive advantage; (2) strategically integrating emerging technologies; (3) securing digital infrastructure and enhancing market transparency; (4) optimizing operational and financial management; and (5) developing customer-centric solutions delivered through digital interfaces.

Although technological innovations present challenges to the real estate sector, they also give companies that adopt them a competitive advantage. Nevertheless, some companies will fail to cope with the competition, particularly since the real estate sector lags behind technological advances by several years (Ullah et al., 2021). However, innovation and technology will not succeed unless real estate companies meet customer needs, since smart real estate must be user-centric (Ullah et al., 2018). Real estate companies must carefully monitor their clients' needs and decide which technologies to invest in (Ocampo, 2024). The slow pace of change is often rooted in the psychological resistance of key decision makers and the absence of adequate training to foster digital confidence throughout the organisation. Traditional managerial mindsets have hindered progress, but the sector must adopt advanced digital technologies to transform into smart real estate in line with Industry 4.0 requirements.

The successful adoption of PropTech is greatly influenced by regional organisational bodies that foster innovation and collaboration. PropTech Lithuania is a network of innovators and market leaders. Its core mission is to cultivate the domestic PropTech ecosystem and drive innovation by connecting stakeholders of all levels, from start-ups to established market leaders. PropTech Lithuania plays a crucial role in facilitating international growth by building global networks and actively attracting foreign PropTech companies to Lithuania. PropTech Lithuania is leveraging this robust network and progressive structure to partner with other organisations and extend its strategic analysis across the broader Baltic region (PropTech Lithuania, 2025).

The literature review consistently emphasised the critical importance of PropTech for the future viability of the real estate sector and its professional roles. However, effective adoption requires crucial alignment between favourable human-designed policy environments and robust technical standards. Financial commitment is limited due to the absence of standardised

productivity data, which makes it difficult to anticipate future investment returns reliably and affects investor confidence. Due to these complex dependencies, where technological success relies heavily on external human factors such as policy and verifiable financial metrics, academic discourse currently lacks a unified, cross-regional, empirical comparison of adoption factors and the specific human and organisational risks in Baltic markets. The necessity of empirical research to assess the viability of current adoption and the quantifiable organisational and human barriers facing PropTech solutions in nascent markets such as the Baltic region is underscored by this reliance on verifiable financial metrics and supportive regulatory structures.

Technology adoption is primarily a human process involving cognitive, organisational and social elements (Xu & Lu, 2022). This study uses the Human-Technology-Organisation (HTO) framework to suggest that successful adoption requires alignment across individual, technological, and organisational factors (Olofsson Hallén et al., 2023). The framework emphasises that adoption is a sociotechnical process with significant implications for professional identity, work processes, and occupational well-being. The Technology Acceptance Model (TAM) and its successor, the Unified Theory of Acceptance and Use of Technology (UTAUT), have both identified perceived usefulness and perceived ease of use as the primary psychological predictors of technology adoption, regardless of the technology's actual performance (Venkatesh & Davis, 2000; Venkatesh et al., 2003).

Incorporating new technology like PropTech into real estate work entails cognitive shifts in professional roles. Automating routine tasks changes the nature of cognitive work from procedural to oversight, requiring new competencies in data analysis, system management, and human-AI interaction (Siderska et al., 2023). This shift can create professional anxiety if not accompanied by adequate training and support, leading to potential resistance, underuse, or even rejection of the technology (Wang, 2022).

This study operationalises this framework by surveying: (1) perceived applicability of PropTech in various professional functions, as a measure of alignment with work processes; (2) barriers to adoption with an emphasis on human capital limitations; and (3) attitudes towards AI as a proxy for technology acceptance and psychological readiness.

The research in this paper aimed to:

- Elicit the views of professionals on how PropTech technologies align with professional work functions, and identify where PropTech enhances or hinders human core competencies in Baltic States' real estate markets.
- Explore and analyse the human and organisational factors influencing the adoption of PropTech, particularly with regard to knowledge and skill gaps and awareness.
- Identify professionals' opinions on artificial intelligence and automation to understand their potential impact on workforce adjustment and professional identity in PropTech-driven real estate organisations.
- Offer a data-informed discussion to inform a more human-centred approach to PropTech investment and human capital development.

The paper's main aim is to conduct a comprehensive comparative analysis of the Baltic region to determine the current landscape of PropTech technology needs and development. It will also assess the risks impacting the technology's long-term viability and the sustainability of human expertise within the evolving industry.

Success Factors for PropTech in the Real Estate Market

The deployment of PropTech technology in real estate is a relatively new field, and comprehensive research is still emerging. While its potential is transformative, the industry's fragmentation and the limited coverage of diffusion theory pose significant challenges to its efficient implementation and adoption (Shirowzhan et al., 2020). Success hinges on fully understanding the factors that govern adoption, which goes beyond technological capability to include institutional and human readiness (Qiu et al., 2023).

The viability of PropTech begins with aligning with macro-level imperatives, such as transitioning to high-quality development and achieving strategic modernisation goals. Institutional commitment is demonstrated through a focus on environmental, social, and governance (ESG)/sustainability; proactive research and development (R&D) investment; and fostering a co-creation model between established enterprises and start-ups (Ladha & Ladha, 2025; Petrescu et al., 2025; Tan & Miller, 2023). These external factors establish the essential strategic mandate and necessary resource foundation.

Industry-wide digitalisation and intelligence depend heavily on the strategic deployment of core digital technologies. This pillar requires integrating big data, artificial intelligence (AI), cloud computing, and blockchain technology to create new productive forces (Jacob & Asha, 2023; Oza et al., 2024; Zhang et al., 2025). The primary technical challenge is to ensure interoperability, enabling systems like BIM to efficiently exchange data with other PropTech platforms and facilitating seamless data flow (Pham Van et al., 2025).

To succeed in PropTech, it must be treated as a comprehensive human-technology-organisation (HTO) social system, considering all three elements together. Organisational leadership must actively promote cross-functional collaboration, implement technical standards and foster positive employee-technology interactions. These efforts can transform investments into systemic, holistic change across the organisation (Olofsson Hallén et al., 2023). Ultimately, however, adoption depends on the individual user. To facilitate this, it is necessary to assess user characteristics, develop team competencies and address technology acceptance (Olugboyega et al., 2024). Acceptance can be gauged through satisfaction and perceived usefulness in order to pre-empt resistance. The final essential measure of successful implementation and realising value is ensuring the project team embraces and utilises the technology effectively (Wang, 2022).

Therefore, the success of PropTech is determined by an interdependent microenvironment that spans institutional strategy, technology integration, organisational systems, and individual readiness. Effective adoption requires holistic alignment across four core pillars:

- External and institutional factors.
- Factors related to PropTech technology.
- Factors related to the project team and organisation.
- Factors related to individual user readiness.

PropTech technology is a transformative force. However, the industry's fragmentation poses significant challenges to efficient implementation and adoption (Shirowzhan et al., 2020). Although many applications for advanced construction and real estate technologies have been recommended in scholarly literature, comprehensive coverage of the process of their widespread integration remains limited. Success hinges on predicting the behaviours of adopters and identifying which components require additional effort for the successful

integration of BIM and other advanced construction and real estate technologies (Khan et al., 2024). Predicting these behaviours depends on understanding compatibility – the degree to which technology aligns with users' experiences, needs, and values (Kim et al., 2022; Kim & Kim, 2021). As these technologies are designed for people, the primary objective is to accurately assess user characteristics and current task performance. This user-centric approach is vital for minimising professional disruption and maximising employee acceptance and satisfaction when introducing new tools. Developing tools that genuinely enhance and simplify the user's workflow ultimately elevates professional fulfilment and drives long-term organisational value through improved human performance.

Analysing the potential success of PropTech reveals a complex microenvironment influenced by multiple factors. Regardless of technological sophistication, the human factor is the most critical consideration for successful adoption (Olofsson Hallén et al., 2023). Since PropTech innovations are designed for people, a core goal of adoption research is to determine the characteristics, interactions, and competencies of individual users in order to develop tools and organisational support that facilitate technology use (Ata et al., 2025; Durdyev et al., 2021). Adopting a human-technology-organisation (HTO) perspective, PropTech is treated as a holistic social system. This acknowledges that technology alone is insufficient for efficient implementation (Tan & Miller, 2023; Xu & Lu, 2022). Consequently, neglecting the individual user in implementation strategies can hinder successful outcomes. As strategic viability now depends on managing these human and organisational complexities, real estate entities must proactively incorporate these insights into their core corporate strategies to ensure both technological adoption and the psychological well-being of their workforce.

Analysis of the scientific literature confirms that the successful deployment of PropTech extends beyond technology. Rather, it is determined by an organisation's strategic commitment and its ability to holistically manage change within key pillars: institutional strategy, organisational systems, and personnel readiness.

RESEARCH METHODS

The study commenced with a review of existing academic literature on the adoption of property technology (PropTech). To collect empirical data, a structured questionnaire was distributed to management executives of companies affiliated with the PropTech Baltics network in January 2024.

The study's sample comprised 20 real estate organisations operating in the PropTech sector across the Baltic States: 10 in Lithuania, 5 in Latvia and 5 in Estonia. To maximise the response rate and ensure adequate representation of the sample, 25 questionnaires were distributed via a combination of email and personal delivery. Twenty of these were returned fully completed and deemed valid responses, resulting in an 80% response rate.

The questionnaire was developed based on an initial literature review to address the study's objectives. Respondents assessed the importance of various factors related to PropTech adoption, challenges, and benefits using a five-point Likert scale. This scale was defined as follows: 1 = Not important, 2 = Less than important, 3 = Important, 4 = More than important, and 5 = Very important.

Analysis of the collected data aimed to determine the ranking of factors according to their relative importance in terms of the applicability and challenges of PropTech. For this purpose, the relative importance index (*RII*) was employed.

The Relative Importance Index (*RII*) is a non-parametric statistical technique used to quantify and rank the relative significance of different factors or variables. This makes it particularly useful for prioritising variables based on their perceived importance in surveys and questionnaires (Binoy et al., 2020; Holt, 2014; Siew et al., 2010). This methodology is well-suited to the present study, as it is commonly employed in research concerning construction (Altuwaim et al., 2023; Fernandes et al., 2024), real estate (Marasinghe & Amarawickrama, 2024; Owusu-Manu et al., 2015) and technology adoption (Alshibani et al., 2024; Desai et al., 2025). In these fields, data is typically gathered from structured questionnaires to determine consensus on the drivers of a given outcome.

Ranging from 0 to 1, the *RII* identifies and ranks the most influential factors within the given set. A higher *RII* value indicates a factor that is more critical in terms of PropTech's applicability, and vice versa.

Based on the experts' opinions collected via the survey, the *RII* was computed for each factor using Equation (1):

$$RII = \frac{\sum W}{A \times N} \ (0 \leq RII \leq 1) \qquad (1)$$

where $\sum W$ is the sum of the weightings given to each factor by the respondents (ranging from 1 to 5, where 1 is "not important" and 5 is "very important"); *A* is the highest weight on the scale (i.e., 5); and *N* is the total number of respondents.

The results of the questionnaire survey are shown in Tables 1–2.

RESULTS AND DISCUSSION

The survey targeted 20 executives and managers who are actively involved in PropTech within the Baltic real estate market. The demographic and professional characteristics of this leadership sample are summarized below.

The expert panel was highly experienced and concentrated in the prime working age bracket, with most executives falling between 30 and 49 years old. The vast majority of respondents possessed substantial industry experience (at least five years), and educational attainment was high, with the majority holding a university degree. The sample consisted primarily of male executives, a gender distribution reflecting patterns often observed in global real estate leadership. Importantly, the organisations represented a diverse market structure, ranging from micro-enterprises to small and medium-sized enterprises (SMEs). This combination of deep professional experience, high education, and varied organisational background ensures the experts possess the necessary knowledge and market context to effectively evaluate the applicability and challenges of PropTech in the Baltic real estate market.

The survey results from Baltic real estate companies reveal a dual-device strategy influenced by hybrid working. Managers in both Lithuania and Estonia primarily use laptops and smartphones, reflecting the priority placed on workplace flexibility and mobility. Desktop computers are used less frequently, indicating their diminished status as the default tool due to

this shift towards flexibility. However, when employees need to carry out tasks that require advanced digital technologies, such as intensive data processing, detailed financial modelling or specialised reporting, the desktop computer is overwhelmingly identified as the preferred high-powered solution. Tablet usage consistently ranks last.

Real estate professionals across the Baltic States overwhelmingly rely on digital information in their daily work, yet the specific formats used vary by country. In both Latvia and Estonia, virtually all professionals utilise general digital documents (such as standard office files), confirming a fully digitised workflow for core document management. These countries also demonstrate a strong and consistent commitment to utilising specialised technical data, such as 2D/3D/CAD files. Latvia and Estonia are also largely paperless. Conversely, Lithuania exhibits a distinct pattern: although professionals frequently utilise general digital documents and cloud-based data, they exhibit a much lower reliance on specialised technical files (2D/3D/CAD). Lithuania is also the only country where a significant proportion of professionals still use paper documents and specific mobile apps in their daily work.

The rapid advances in artificial intelligence (AI) and machine learning (ML), particularly the emergence of generative AI, have transformed our perception of digital capabilities. These technologies allow organisations to analyse large volumes of data and produce highly accurate and dependable outcomes (Fourkiotis & Tsadiras, 2023; Kandipati, 2025; Zhao et al., 2024). As FinTech, ConTech and PropTech are expected to transform their respective industries with these new technologies within the next decade (Perera et al., 2025; Tiwari & Miao, 2022), it is essential to evaluate the attitudes of executives.

Professionals engaged with the latest PropTech solutions show a proactive and positive attitude towards artificial intelligence (AI), viewing it primarily as a means of augmentation and efficiency gains, rather than as an existential threat to their role. This positive disposition is substantiated by the finding that the vast majority of respondents indicated that they are not afraid of AI's potential impact. This attitude is consistent with the global trend of real estate professionals rapidly adopting technologies such as ChatGPT to enhance customer service and automate daily tasks. A similar trend can be seen in the construction sector, where professionals began using this technology for their daily tasks soon after ChatGPT's release (Sonkor & García De Soto, 2025). This widespread adoption highlights AI's role as a critical tool for boosting productivity and maintaining competitiveness in the digital economy, rather than as a competitor.

Factors Affecting PropTech Applicability

Utilising the robust knowledge base established by the expert respondents, a formal assessment was conducted to determine the perceived significance of digital transformation. Respondents provided their opinions on the applicability of PropTech across diverse real estate functions. The data was then subjected to the relative importance index (*RII*) analysis to establish an objective ranking of the factors. Table 1 details these findings, representing the collective view of executives and their authorized representatives in Lithuania, Latvia, and Estonia.

Based on the average *RII* across all three Baltic countries, as detailed in Table 1 and visualised in Figure 1, PropTech is perceived as being most applicable in areas that enhance efficiency and data intelligence. Marketing, contract management and interactive billing are definitively the most critical applications (*RII* = 0.973), reflecting a strong consensus among executives on PropTech's core value of automating customer-facing and sales processes. This

is closely followed by data, valuation and analytics (*RII* = 0.927), which validates the industry's shift towards data-driven decision-making.

Table 1. *RII* of PropTech applicability in real estate companies across the Baltic States.

PropTech applicability	Lithuania		Latvia		Estonia		Average *RII*	Rank
	RII	Rank	*RII*	Rank	*RII*	Rank		
Property registry and search services	0.94	2	0.92	3-4	0.76	6-7	0.873	4
Real estate investment and financing	0.8	7	0.92	3-4	0.84	4	0.853	5-6
Marketing, contract management, and interactive billing	0.96	1	1	1	0.96	1	0.973	1
Market analysis and research	0.86	5	0.72	9	0.72	8-9	0.767	8
Alternative business models and events	0.74	9	0.76	8	0.76	6-7	0.753	9
Mortgage lending and loan services	0.92	3	0.84	7	0.8	5	0.853	5-6
Data, valuation, and analytics	0.9	4	0.96	2	0.92	2-3	0.927	2
Energy management and efficiency	0.78	8	0.88	5-6	0.72	8-9	0.793	7
Facility management	0.84	6	0.88	5-6	0.92	2-3	0.880	3

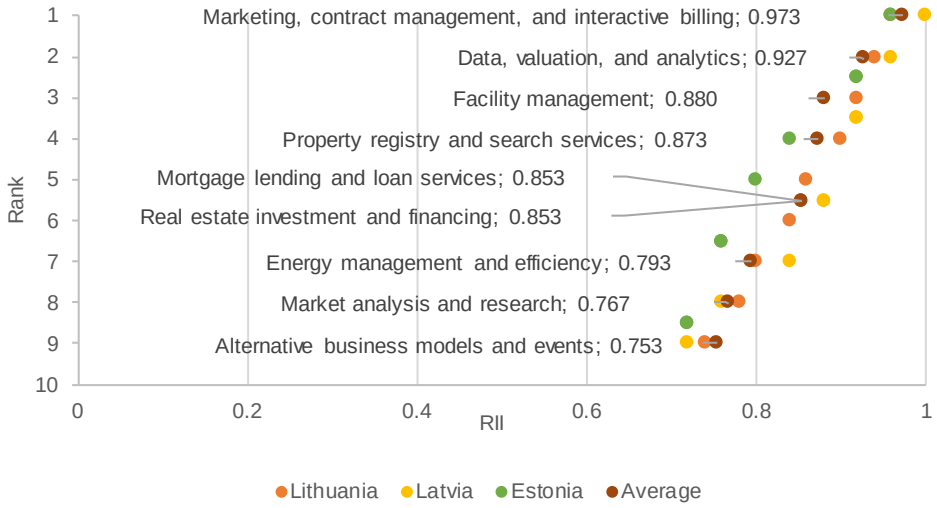

Figure 1. Relative importance (*RII*) and ranking of PropTech application goals in real estate companies across the Baltic States.

Accurate property valuation remains methodologically demanding, as the choice of index construction method significantly affects outcomes (Hill & Trojanek, 2022), reinforcing the need for PropTech tools that ensure analytical rigour. Facility management (*RII* = 0.880), which secures the third-highest rank. This indicates a strong regional commitment to leveraging IoT and smart technologies for reducing operational costs. Conversely, the categories perceived as the least applicable are alternative business models and events (*RII* = 0.753) and market

analysis and research (*RII* = 0.767), suggesting that these are viewed as the least pressing areas for current technological investment.

Significant and instructive variations emerge when the data is analysed at country level. Latvia exhibits the highest consensus on the utility of PropTech in marketing, contract management and interactive billing (*RII* = 1), indicating a universal agreement among its executives to prioritise client-facing digitisation. In contrast, while Lithuania also prioritises marketing, real estate investment and financing receives its lowest score (*RII* = 0.800, rank 7) of all three countries, despite receiving high scores in both Latvia (*RII* = 0.920) and Estonia (*RII* = 0.840). Furthermore, property registry and search services reveal a paradox in Estonia, receiving a low *RII* of 0.760 (rank 6-7), which is notably below the score given by Lithuania (*RII* = 0.940). This likely reflects Estonia's mature e-government market, where the essential property registry function is already highly digitised by the state, limiting the perceived need for further private PropTech innovation in this area.

The top three applicability ratings for marketing, contract management and interactive billing (*RII* = 0.973) provide preliminary insights into the human elements of the equation. PropTech solutions are rated as being most applicable to supporting, rather than replacing, professional activity. More specifically, in client-facing roles that require strong relationships and effective communication, technology is most likely to be seen as a tool that can enhance human capabilities. At the other end of the scale, market analysis and research functions were rated the lowest (*RII* = 0.767), which may indicate an element of cognitive dissonance: while dispassionate data analytics certainly have an objective efficiency case, professionals may also intuitively see them as closely related to their expertise. As such, they may view technology as a more psychologically contentious prospect for mediation. As for country-level differences, Estonia's low score for property registry and related services (*RII* = 0.76) seems to indicate more of a psychological and economic threshold than a technological one. This is a function and market segment that has already experienced mainstream adoption of digitisation through Estonia's advanced e-government framework.

Challenges of PropTech Technology

It is crucial to identify the obstacles to technological integration in order to inform future investment in the region. To this end, survey respondents in the Baltic States were asked to evaluate the relative importance (*RII*) of various difficulties encountered when attempting to implement PropTech solutions in the real estate industry (see Table 2).

Based on the average *RII* across all three Baltic countries, as visualised in Figure 2, it is clear that the implementation of PropTech is overwhelmingly constrained by financial and regulatory hurdles. Insufficient investment capital is undoubtedly the most significant challenge (*RII* = 1.000), reflecting the general view that the environment of high interest rates is the primary financial barrier preventing firms from adopting solutions. This is closely followed by uncertainty regarding legal and regulatory obligations (*RII* = 0.960), which highlights the urgent need to manage the costs of complying with new EU mandates (e.g., ESG reporting). Third place goes to limited internal PropTech knowledge (*RII* = 0.927), highlighting the urgent need to address the human capital and skills gap within real estate firms. Conversely, the categories perceived as posing the least overall constraint are system interoperability challenges (*RII* = 0.673) and data and information security concerns (*RII* = 0.627), suggesting

that while these are technical hurdles, they are currently overshadowed by financial and regulatory pressures.

Table 2. *RII* of PropTech implementation challenges in real estate companies across the Baltic States.

Challenges and difficulties using PropTech	Lithuania		Latvia		Estonia		Average *RII*	Rank
	RII	Rank	*RII*	Rank	*RII*	Rank		
Lack of initiative/proactivity	0.86	7	0.72	9	0.76	8	0.780	8
Insufficient investment capital	1	1	1	1	1	1	1.000	1
Administrative costs	0.74	9	0.76	8	0.72	9	0.740	9
Training and upskilling costs	0.78	8	0.8	7	0.88	4-5	0.820	7
Limited internal PropTech knowledge	0.94	3	0.92	3	0.92	3	0.927	3
Shortage of PropTech-skilled staff	0.92	4	0.88	4-5	0.88	4-5	0.893	4
System interoperability challenges	0.7	10	0.68	10	0.64	10	0.673	10
Data and information security concerns	0.68	11	0.6	11	0.6	11	0.627	11
Uncertainty regarding legal/regulatory obligations	0.96	2	0.96	2	0.96	2	0.960	2
Lack of external collaboration/partnerships	0.88	6	0.88	4-5	0.8	7	0.853	6
Absence of required hardware/infrastructure	0.9	5	0.84	6	0.84	6	0.860	5

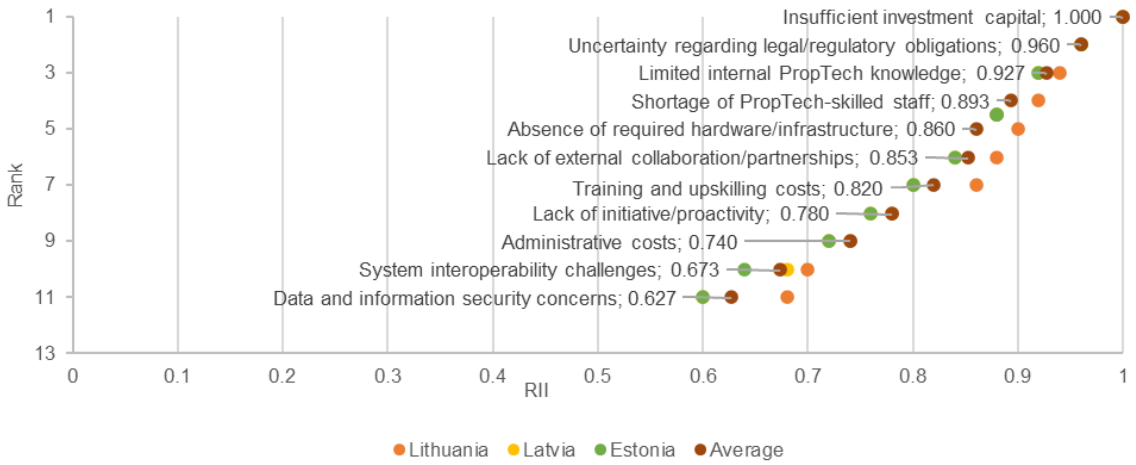

Figure 2. Relative importance (*RII*) and ranking of PropTech application goals in real estate companies across the Baltic States.

The cross-country comparison reveals that, while the top three constraints are universally shared, significant variations emerge in technical and human-factor priorities. Executives from all three countries unanimously agree that insufficient investment capital (*RII* = 1.000) and uncertainty regarding legal and regulatory obligations (*RII* = 0.960) occupy the top two ranks, highlighting the significant pressure exerted by the current economic and regulatory environment. However, training and upskilling costs are perceived as significantly more

difficult in Estonia than in Lithuania and Latvia. Estonia ranks this challenge highly at *RII* = 0.88 (rank 4-5), prioritising it significantly more than Lithuania (*RII* = 0.78, rank 8) and Latvia (*RII* = 0.80, rank 7). Conversely, data and information security concerns and system interoperability challenges are unanimously deemed the least important barriers, occupying the bottom two ranks (rank 10 and 11) across all nations. Lack of initiative/proactivity is considered a minor obstacle in Lithuania (*RII* = 0.86, rank 7), but is ranked lower in both Latvia (*RII* = 0.72, rank 9) and Estonia (*RII* = 0.76, rank 8). These findings suggest that, while technical issues are not considered the main obstacle, the low ranking of lack of initiative may indicate an underlying behavioural or cultural issue within organisations. This could imply psychological resistance to change or a need for stronger management support for innovation. Furthermore, limited PropTech knowledge among staff creates a significant cognitive gap, which can lead to professional uncertainty and increased human error in complex system interactions. Therefore, overcoming these soft challenges associated with human capital, organisational motivation and training confidence is crucial for the successful implementation of PropTech.

The most interesting insights come from the barrier analysis. In all countries, human issues are the main obstacle to PropTech adoption. Although a lack of capital ranks top (*RII* = 1.000), the next three barriers are all human-related issues concerning cognition, skills, and organisational learning: regulatory uncertainty (*RII* = 0.960), limited internal knowledge (*RII* = 0.927), and staff skill shortages (*RII* = 0.893). These human barriers significantly outrank technical barriers such as system interoperability (*RII* = 0.673) and data security (*RII* = 0.627).

This implies that PropTech adoption is constrained by professional readiness rather than technology readiness. The gap between new digital tools and existing professional knowledge can result in information overload for staff using unfamiliar technologies, leading to errors, frustration, and the eventual rejection of new technologies. Training costs are ranked higher in Estonia (*RII* = 0.88) than in Lithuania (*RII* = 0.78), which could reflect a more realistic understanding of the costs and labour involved in upgrading staff skills. Paradoxically, the more digitally mature the market, the more aware it is of the significant training costs required to keep up with fast-developing, high-tech solutions.

The low overall ranking for a lack of initiative in all countries (with rankings ranging from 7 to 9) challenges the idea of professional resistance to change. Rather than negative attitudes being a barrier, the data suggests that the more pressing constraints to PropTech adoption are structural and relate to capital, knowledge or skills. With the right support, professionals are willing to adopt PropTech, which is consistent with the HTO model's focus on organisational enablers.

Prospects for the Adoption of the PropTech Technology

Despite existing challenges and difficulties associated with implementing PropTech innovations in Baltic real estate companies, industry experts generally accept the viability and applicability of this technology within Lithuania's real estate sector. This strong professional consensus indicates a positive long-term outlook for digital transformation in the region.

The adoption of PropTech in future real estate operations is expected to prioritise intelligence, automation and efficiency, and follow several key developmental paths. These paths focus on improving the sector's analytical and operational capabilities.

Intensifying the focus on intelligence and valuation will involve implementing sophisticated data control and analytics to optimise operations and property valuations. Furthermore, advances in augmented reality (AR) will play a pivotal role in enhancing the visualisation and design of properties, bridging the gap between digital models and physical structures. Another key growth area is operational automation, where smart buildings and the deeper integration of building robotics and mechanisation are set to increase significantly. Technologies focusing on automated construction, repair, and building management – such as predictive maintenance systems – are expected to reduce the need for manual labour significantly, bringing about substantial efficiencies and positive changes.

CONCLUSIONS

The field study yielded several critical insights into the readiness and challenges of the Baltic real estate sector regarding PropTech adoption:

- According to executives from the real estate industry, PropTech has the greatest immediate applicability in three high-value functional areas that define the sector's priorities for transactional efficiency and intelligence. Marketing, contract management and interactive billing are the top priority, highly valued for their direct business impact, which is achieved by automating customer-facing processes, accelerating sales cycles and significantly improving cash flow. The second key area is data and valuation analytics. This is crucial for reducing financial risk, generating predictive market insights, and ensuring accurate property valuations, all of which are essential for lending and investment decisions. Finally, facilities management translates directly into tangible benefits by reducing operational expenditure, maximising asset lifespan and supporting sustainability goals through energy optimisation and predictive maintenance.
- The most significant obstacle identified by all real estate professionals is the lack of investment funds, which hinders the initial implementation and subsequent improvement of PropTech solutions. This financial obstacle is immediately followed by three structural barriers that complete the executive risk matrix: uncertainty regarding legal and regulatory obligations (driven by EU ESG mandates); limited internal PropTech knowledge; and a shortage of PropTech-skilled staff.

Successfully activating and scaling PropTech technology across the region requires a concerted focus on several strategic areas. These include increased education and training, leveraging knowledge and experience from abroad through partnerships and study tours, initiating in-service training programs, hosting conferences, launching focused pilot projects, facilitating networking, and fostering collaboration among various project participants.

The speed at which PropTech is implemented in the real estate sector of the Baltic States depends on several critical factors, as revealed by the field study. These factors are unique to the current market context:

- Sustained capital commitment and strategic allocation of resources towards innovation, particularly in real estate start-ups;

- Visionary leadership coupled with deep technical expertise within the implementation team;
- Customer-centric agility for rapid adaptation to market volatility and evolving customer demands.
- Robust project governance and quality assurance mechanisms for innovative solutions.
- Organisational commitment to ensuring extensive application across many work spheres.

Overall, the findings confirm a very high underlying demand and significant potential for the expansion of PropTech technology within the Baltic region, despite the noted challenges.

IMPLICATIONS

The findings of this study provide a valuable blueprint for the future theoretical development, practical application and policy formulation relating to the adoption of PropTech. Specifically, the insights derived from the Baltic market's unique experience – characterized by high digital readiness and acute capital constraints – provide a directly applicable model for other emerging PropTech markets navigating the initial stages of technological implementation.

Future research should focus on developing longitudinal models that can accurately track PropTech maturity in the Baltics while addressing the difficulty of predicting successful scaling scenarios. While the *RII* method effectively ranks quantitative perceptions, future research could greatly benefit from the addition of qualitative methods, such as in-depth interviews, to explore the reasons behind these executive rankings and capture the human, social and psychological factors that influence adoption (Gimbel & Newsome, 2015). Nevertheless, the *RII* technique was suitable for this analysis, as its robust capacity for prioritising and achieving consensus on key factors provided the necessary quantitative basis for evidence-based policymaking and subsequent, more in-depth qualitative research. Scholars must also investigate the measurable impact of AI applications on real estate valuation and efficiency, linking professional acceptance with quantifiable productivity gains, given the high internal demand. The Baltic region's specific challenges, particularly regarding funding and skills shortages, necessitate comparative studies with more established PropTech markets. These comparisons are vital for providing a robust blueprint that will help other emerging economies to identify the most effective strategies for overcoming limited access to capital and specialised personnel during the initial stages of adoption.

Practitioners should use the identified strategic areas as a direct roadmap for acceleration. In order to bridge the skills gap, education, training and knowledge transfer from abroad must be prioritised. Scaling PropTech requires prioritising critical factors, such as allocating resources to real estate start-ups and ensuring that the team and leadership possess first-rate technical skills. This approach yields direct human benefits:

- Professionals benefit from reduced administrative tasks, enabling them to focus on strategic activities and personalised client relationships, thereby boosting job satisfaction and overall productivity.
- Automating repetitive tasks enables skilled staff to engage in high-value problem solving, leading to greater professional fulfilment and higher employee retention rates.

- Access to immediate, accurate data and predictive analytics empowers managers and sales agents to make more informed decisions, reducing errors and improving transactional reliability.
- High-applicability areas increase market transparency, lower investment barriers and provide clients and users with more flexible, cost-effective services.

This practical roadmap is valuable not only for the Baltic States but serves as a directly applicable blueprint for any other developing real estate market that is actively transitioning toward a data-driven, client-centric service model.

Policymakers in the Baltic States should prioritise designing targeted incentives to address the critical lack of investment funds. This can be achieved by establishing specific funding mechanisms or grants for start-ups innovating in the real estate sector. At the same time, the authorities must support the development of specialised educational programmes and certification schemes in PropTech to address recognised knowledge and skills gaps. Collaborating with industry associations is also essential for facilitating the transfer of expert knowledge. Addressing these deficits in investment and skills through targeted policy interventions will create a highly efficient market, yielding significant societal benefits such as more accessible housing, transparent transaction processes, and a higher-quality built environment for all citizens.

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