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Listed Real Estate in European Insurers' Portfolios

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EXECUTIVE SUMMARY

This study examines the role of listed real estate within mixed-asset portfolios of European insurers, which represent the region's largest institutional investors by assets under management (AUM). While existing academic research to date has focused mainly on pension funds, comparatively little attention has been paid to insurance companies, despite their distinct regulatory constraints and liability-driven investment objectives. This study addresses that gap by analysing the diversification benefits and optimal portfolio allocations of listed real estate from an insurer's perspective.

We assess listed real estate alongside unlisted real estate and direct real estate, applying both mean-variance optimisation and asset-liability modelling (ALM) to capture insurers' liability-driven investment needs. As a listed asset class, real estate forms part of insurers' equity allocation, making its role particularly relevant under the Solvency II Long-Term Equity (LTE) framework. The analysis is therefore relevant not only from a real estate perspective, but also in the context of insurers' broader LTE allocation.

In the standard mean-variance analysis, which treats each form of real estate as a complementary asset within the portfolio, allocations to listed real estate seem to be limited and concentrated around the middle of the efficient frontier, while unlisted real estate provides significant diversification benefits along the efficient frontier. However, this asset-only perspective does not capture insurers' liability-driven investment objectives.

When liabilities are considered, the benefits of listed real estate become more pronounced and emerges as the most effective hedge: it exhibits the strongest correlations with liabilities and achieves the highest liability-hedging credits across all scenarios. These results are robust across three liability proxies—total liabilities, technical provisions, and duration-matched portfolios. Under ALM models with Solvency II consistent assumptions, suggested optimal allocations to listed real estate range from 6.51% to 16.29%, depending on model specification, liability proxy and risk appetite. This exceeds the current average allocation of 1.51%. These results suggest that listed real estate can contribute meaningfully to insurers' strategic asset allocation decisions while remaining compatible with regulatory capital requirements.

Despite behaving like direct real estate in the long run, Solvency II treated listed real estate as short-term equity. We show that eligibility for the LTE treatment under Solvency II, which applies a 22% capital charge to listed real estate compared with the 39% stress in the standard formula, increases its allocation and improves the performance of the optimal portfolio with the highest risk-adjusted surplus, while leaving the lowest-risk portfolio largely unaffected. Results are mostly robust, though estimates show greater variability during periods of market disruption such as COVID-19 pandemic and the Russia-Ukraine war. Finally, as listed real estate is a recognised hedge against inflation—particularly expected inflation—we argue that this underpins its liability-hedging benefits, given that insurers' liabilities are nominal and move with inflation. Unlike direct real estate and unlisted real estate, listed real estate is more liquid, and our findings also indicate that insurers prefer

larger listed firms, which offer greater liquidity. Our results highlight that listed real estate delivers risk-return characteristics that are broadly comparable to alternative real estate routes, while providing distinctive liability-hedging advantages and superior liquidity.

Overall, the findings demonstrate that listed real estate represents a valuable and underutilised component of European insurers' portfolios. By improving diversification, enhancing risk-adjusted surplus, and offering operational flexibility, listed real estate complements both traditional financial assets and unlisted property investments. Taken together, the findings suggest that listed real estate may be more relevant to insurers' strategic asset allocation than current portfolio weights imply, particularly when viewed through an ALM and regulatory lens. These results provide practical insights for insurers, asset managers, and regulators seeking to better understand the role of listed real estate within liability-driven investment frameworks.

Content table

Exeutive Summary	2
1. Introdcution	4
2. Literature Review	7
3. Research Motivation	9
4. Methodology	9
5. Data Analysis	11
6. Portfolio Analysis	12
7. Robustness Check: Alternative Proxy for Liability	17
8. Summary of Liability Hedging Features	18
9. Effective Regulatory Change	19
10. Drivers of Institutional Investment in Listed Real Estate	21
11. Future Research Avenues	23
12. Conclusion	24
References	25

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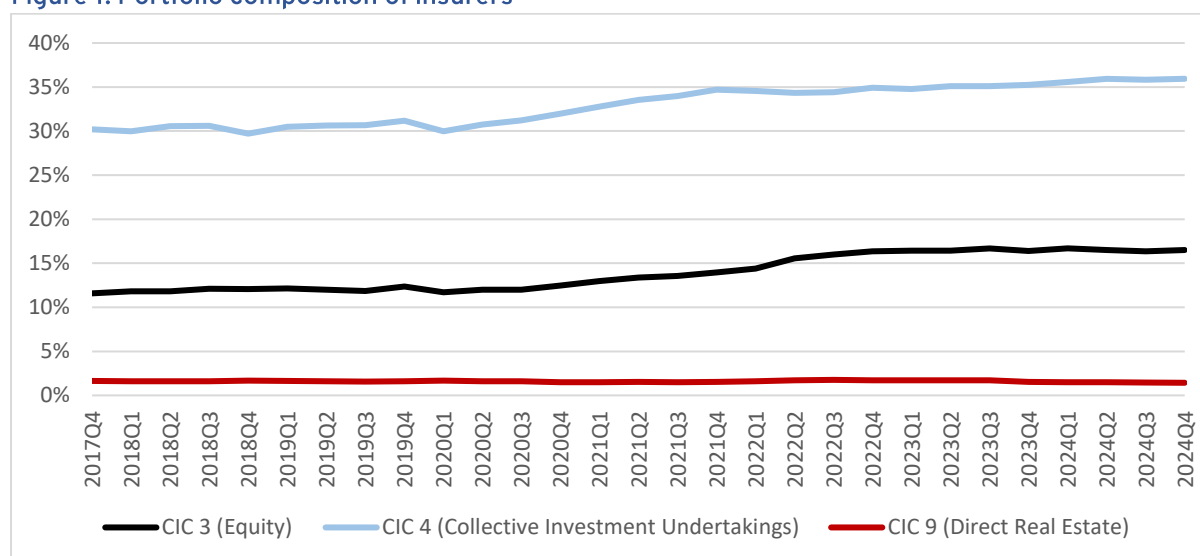
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1. Introduction

The role of real estate in mixed-asset portfolios has been extensively explored in the literature. However, much of this research has focused on the implications of asset allocation for pension funds, with comparatively little attention paid to insurance companies. This presents a significant gap, particularly in the European context, where—unlike in the United States—insurance companies represent the largest segment of institutional investors by AUM.¹ To address this, our research examines real estate allocations within mixed-asset portfolios from the perspective of European insurers, for whom liability matching, capital efficiency and regulatory treatment are central to strategic asset allocation decisions.

Figure 1 presents the time-varying asset allocations, across selected Complementary Identification Code (CIC) categories - specifically-CIC 3, CIC 4 and CIC 9 where direct real estate, listed real estate and unlisted real estate lies in the portfolios of European insurance companies², reported by the European Insurance and Occupational Pensions Authority (EIOPA). The data reveals a gradual increase in allocation to equity investments (CIC 3) from around 11.6% to 16.5% and collective investments undertakings (CIC 4) from around 30% to 36%. At the same time allocation to direct real estate (CIC 9) remain broadly stable but display a modest decline over time across European insurers.

Figure 1. Portfolio composition of insurers



Note: The data is collected from asset exposures of EIOPA (2025) based on Q4 2017 to Q4 2024.

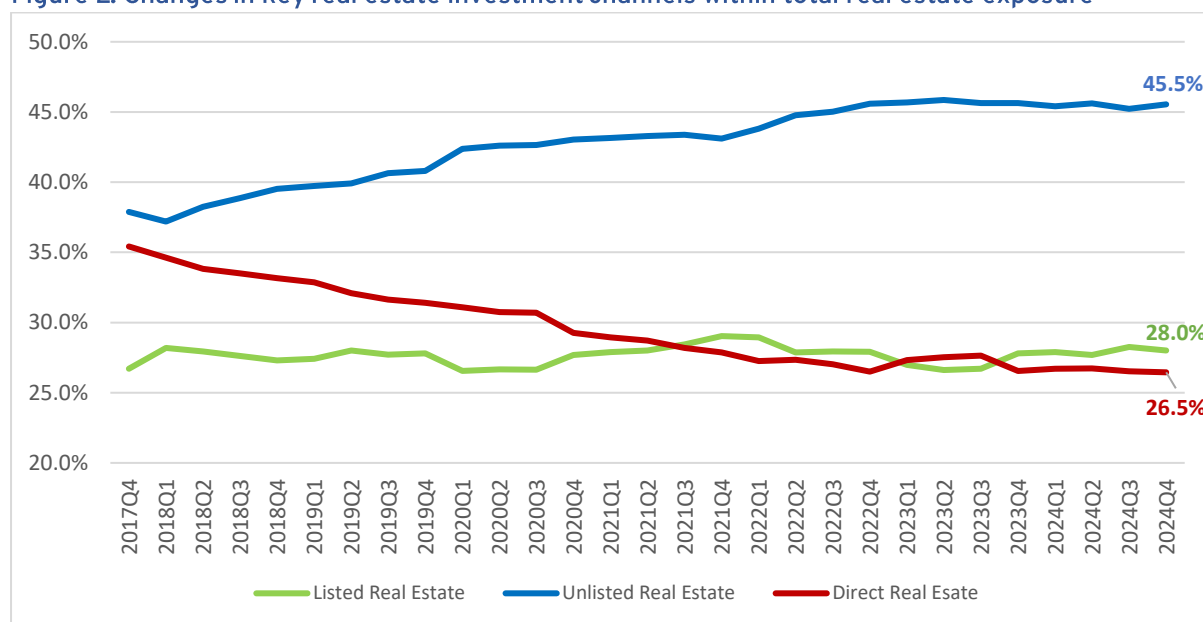
To gain further insight into insurers' real estate investment behaviour, we examine the changes in the composition of total real estate exposures across three real estate investment routes—listed real estate in CIC 3 (equity), unlisted real estate in CIC 4 (collective investment undertakings), and direct real estate in CIC 9. As illustrated in Figure 2, we observe a relatively stable, albeit slightly increasing, allocation to listed real estate, ranging from approximately 26.6% to 28%, and to unlisted

¹ According to EIOPA (2024), the total reached approximately EUR 9.6 trillion as of Q2 2024.

² This analysis includes statistics from 10 European countries: Austria, Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Norway, and Sweden. The UK is excluded, as data is only available from Q4 2017 to Q4 2020. However, the conclusion remains unchanged when the UK is considered.

real estate, increasing from around 37.2% to 45.5% over the sample period. By contrast, the allocation to direct real estate has consistently declined, falling from 35.4% to 26.5% in recent years. These trends indicate a clear shift in insurers' preferences towards indirect real estate vehicles, such as listed and unlisted assets, over time.

Figure 2. Changes in key real estate investment channels within total real estate exposure



Note: The data is collected from asset exposures of EIOPA (2025) based on Q4 2017 to Q4 2024. Figures report allocation to direct, listed and unlisted real estate within these total real estate exposures.

Our results are consistent with recent evidence from pension funds reported in Carlo et al. (2024), which finds that portfolios of physical real estate assets have generally been declining. We further examine the breakdown of results across 10 European countries.³ Although the allocation to listed, unlisted, and direct real estate varies across countries, the trend towards increasing appetite for listed real estate remains robust. In Norway and Sweden, listed real estate plays a particularly prominent role, comprising more than 50% of real estate portfolios, while direct real estate allocations have declined over time. By contrast, in the other eight countries (excluding Denmark), listed real estate does not dominate real estate portfolios; however, the pattern remains similar, with growing allocation to listed real estate accompanied by declining allocation to direct real estate.

Listed real estate is often favoured over direct real estate due to its feasibility, lower transaction costs, liquidity, and simplified management. Listed real estate indices are tradable, unlike valuation-based direct real estate indices, which are difficult to track—especially for small portfolios. Transaction costs are substantially lower: stamp duty on UK Real Estate Investment Trust (REIT) shares is 0.5% versus up to 5% for non-residential property transactions. Moreover, listed real estate avoids intensive property management and offers superior liquidity, with trades executed promptly, compared to median completion times of 104 days for direct real estate purchases (Devaney & Scofield, 2015). While REITs tend to behave like equities in the short term, their long-run performance

³ The 10 countries are Austria, Belgium, Denmark, France, Germany, Ireland, Italy, the Netherlands, Norway, and Sweden.

aligns closely with underlying real estate (Hoesli & Oikarinen, 2012). Investing in listed real estate also provides access to the strategic, managerial, and retrofit capabilities of specialist real estate companies (Moss & Baum, 2013). These skills are crucial for upgrading assets, mitigating obsolescence risk, and delivering modern, lower-carbon buildings – advantages that passive direct ownership of direct real estate may not provide.

Given the advantages of listed real estate and the relative lack of portfolio analysis specific to insurers, our research seeks to address the following key research questions. First, what is the theoretically recommended allocation to listed real estate in a mixed-asset portfolio, and how does this differ from insurers' actual allocations? Second, how do the EU's Solvency II regulations impact insurers' allocations to real estate? Third, what factors shape institutional investors' decisions to allocate capital to listed real estate? By addressing these questions, we aim to evaluate the extent to which listed real estate can enhance insurers' portfolio performance and to better understand the drivers of investment decisions in this asset class.

Our analysis begins with a classic mean-variance optimisation, using quarterly data from Q1 2008 to Q4 2024. We compare the role of three different routes into real estate—direct real estate, listed real estate, and unlisted real estate—within a mixed-asset portfolio. When treated as substitutes, all three real estate investment routes improve the efficient frontier, thus within an asset-only framework, unlisted real estate receives higher allocations. However, this framework does not capture insurers' liability-driven investment approach, and therefore provides only a partial view of the role of listed real estate in practice.

As insurers must meet long-term liabilities, we extend the classic mean-variance optimisation to incorporate liabilities and apply two types of Asset-Liability Modelling (ALM) frameworks: one focusing on minimising the risk of a shortfall in assets against liabilities, and another incorporating liability hedge credits. In our modelling, we also impose assumptions including capital requirements and solvency ratios, in line with Solvency II regulations, to ensure that the results provide practical insights applicable to insurers. The actuarial liability benchmark data is collected from EIOPA, which restricts the sample period to Q4 2016-Q4 2024, due to data availability. Under ALM, we find a significant role for listed real estate, with optimal allocations ranging from 6.51 % to 16.29%, depending on the model specification, liability proxies and risk appetite. Higher allocations are observed in portfolios with greater tolerance for risk. By contrast, direct real estate continues to play little or no role, as its contribution is largely absorbed by unlisted real estate.

Our results are consistent with observed allocation trends, showing a strong preference for listed and unlisted real estate over direct real estate. While the performance of listed real estate is broadly comparable to that of direct or unlisted real estate, it offers additional advantages, including superior liquidity, lower transaction costs, and greater market transparency. These characteristics enhance portfolio flexibility and enable more efficient rebalancing in response to changing market conditions. In this way, listed real estate serves as a valuable complement to direct real estate exposure, supporting liability-driven investment strategies while maintaining access to real estate's diversification benefits.

As evidenced in our results, listed real estate provides a strong hedge against liability risk. This hedging ability in nominal terms can potentially be explained by listed real estate's capacity to hedge against inflation, as documented in the literature. Correlation analysis and our imputed liability hedge credits further confirm that listed real estate has the strongest association with liability proxies relative to other real estate types. These findings remain robust irrespective of three liability proxies—actuarial total liabilities, technical provisions, and duration matched liabilities.

It is well established that REITs tend to behave more like equities in the short term but exhibit direct real estate like characteristics in the long run. Yet, Solvency II treated listed real estate as

short-term equity holdings, which may may not fully reflect its long-term investment characteristics. We therefore consider the effective change in 2019 when the European Commission significantly amended the Solvency II Delegated Regulation to establish a dedicated, lower capital charge for LTE investments, including listed real estate. Our full-sample result shows that this adjustment enhances the performance of optimal portfolios with the highest risk-adjusted surplus by incorporating higher listed real estate allocation. We also conduct a sub-period analysis using a five-year rolling window with one-year step to test the allocation sensitivity towards the reduced capital requirement due to long-term holding periods. The results can be sensitive for some periods, reflecting the fact that the sub-samples span major shocks such as COVID-19 pandemic and the Russia-Ukraine war. Finally, we complement our analysis by considering insurers' preferences for listed real estate and find that they favour larger listed real estate companies, which offer greater liquidity. The liquidity advantage is one of the key factor underpinning insurers' preference for listed real estate over other types of real estate. Altogether, this report documents the important liability-hedging role of listed real estate within mixed-asset portfolios. The remainder of the report is organised as follows:

- Section 2 reviews the literature.
- Section 3 explains the research motivations.
- Section 4 describes the methodology.
- Section 5 presents the summary statistics.
- Section 6 provides the portfolio analysis.
- Section 7 reports the robustness checks.
- Section 8 compares liability hedging features across assets.
- Section 9 examines the effective regulatory changes.
- Section 10 focuses on insurers' investment decisions.
- Section 11 discusses potential research avenues.
- Section 12 concludes.

2. Literature Review

Real estate has long played a central role in diversified investment portfolios, reflecting its distinctive characteristics and long-standing institutional participation. These discussions typically distinguish between two types of real estate exposure in a mixed-asset portfolio: direct and indirect. Unlike financial assets, direct real estate is a heterogeneous, tangible asset traded in private markets. The distinctive characteristics of real assets compared to financial assets have made them potential risk diversifiers in portfolio management (Lin & Fuerst, 2014; Lin & Stankov, 2026). Moreover, direct real estate offers robust capital returns and stable income returns, which are beneficial for institutional investors in meeting their liabilities (Johner & Hoesli, 2025). Real estate also remains attractive to large institutional investors such as pension funds and insurance companies due to their long investment horizons, which enable them to capitalise on the illiquidity premium associated with such assets. Finally, real estate is known to be a good hedging asset against inflation (Hardin et al., 2017; Lin, 2018; Lin & Robberts, 2024). As summarised by Seiler et al. (1999), several studies suggest a typical allocation to direct real estate of around 15% to 20%, although this varies depending on modelling assumptions and sample periods. Similar results can be seen in more recent literature, as discussed below.

Unlike direct real estate, listed real estate offers investors a means of investing in direct real estate without the problems typically associated with direct real estate, such as high unit costs, illiquidity, and intensive management (Ciochetti et al., 2002). The examination of the role of listed real estate in a mixed-asset portfolio can be traced back to Kuhle (1987), who finds that REITs do not significantly improve the performance of a portfolio composed solely of common stocks for the period from 1980 to 1985. In contrast, Mueller et al. (1994) as well as Mull and Soenen (1997) show that the value of REITs as an asset class in a portfolio is time-varying. REITs would appear more attractive for relatively more aggressive investors. Motivated by the impact of investment horizons, Lee and Stevenson (2005) investigate the role of REITs in mixed-asset portfolios over various holding periods. They find that the diversification benefits of REITs increase with longer holding periods. Their diversification attributes are evident across the entire efficient frontier, offering return enhancement in conservative portfolios and transitioning to risk-mitigation effects in more aggressive portfolios. More recently, Muller and Muller (2024) report that direct real estate accounts for around 20% of conservative, low-risk portfolios and up to 48% in more aggressive, high-risk portfolios. In contrast, REITs are primarily included in higher-return portfolios, with an average allocation of about 23%. Extending this line of research, Hoesli et al. (2025) show that, for tactical allocation purposes, listed real estate tends to receive a higher weighting in mixed-asset portfolios when diversification is pursued across sectors rather than across countries.

One key strength of including listed real estate in the portfolio is their ability to hedge against inflation, as real estate can typically deliver a sufficient inflation hedge through two channels: lease payments (income return) and land values and building costs (capital gain return). Though results are mixed in earlier studies, recent studies, using more robust data and methods, find strong inflation-hedging benefits. Gyourko and Linneman (1988) report that REITs have a negative correlation with inflation and behave like equities and bonds. Using different inflation measurements, Park et al. (1990) draw a similar conclusion that REITs' inflation-hedging benefits are like those of equities, though REITs can partially hedge against expected inflation. Titman and Warga (1989) propose a different view, suggesting that REITs function as a paradoxical hedge—they appear to anticipate rather than respond to inflation, as equity REIT returns tend to move ahead of future inflation rates. Consistent with Hardin et al. (2012), Lee and Lee (2012) show that REITs began to hedge expected inflation after the 1993 structural break, when tax reforms made large-scale REIT investments more attractive to institutional investors. Muckenhaupt et al. (2025) resolve the mixed findings by showing that the hedging capacity might have been underestimated previously due to index issues of rent components. Using a Markov switching vector error correction model, they show that listed real estate are a good hedge against expected inflation in the long term. They also show that listed real estate plays an important role in inflation-hedging portfolios.

Although listed real estate are traded as real estate securities, they are known to behave like equities in the short term, while in the long term, their performance aligns more closely with the underlying direct real estate (Hoesli & Oikarinen, 2012). A series of studies have suggested that they are substitutes for one another. Using a paired-comparison t-test, Pagliari et al. (2005) report no significant difference between returns from the direct real estate and de-leveraged REIT indices in the US. Similarly, Oikarinen et al. (2011), employing a co-integration approach, arrive at the same conclusions. Taking a slightly different approach, Horrigan et al. (2009) suggest that REITs can serve as effective proxies for replicating the performance of private real estate portfolios in the US. Based on evidence from six countries, Hoesli and Oikarinen (2021) show that over the medium to long term, listed and direct real estate returns display similar characteristics and respond similarly to economic shocks. This suggests that investors can effectively track broad international direct market

performance through listed real estate without being overly concerned about compositional differences.

Another route to invest in the indirect real estate is through the non-listed real estate funds. Using the US data, Delfim and Hoesli (2019) provide comprehensive comparisons of the role of different types of real estate in mixed-asset portfolios for different investment horizons. For investors with a medium- to long-term horizon, they recommended that around 20% of their portfolio be allocated to direct real estate. In contrast, those with a short-term focus may benefit more from investing in open-end core funds, which can serve as effective alternatives to direct real estate investments. While listed real estate may not be full substitutes for direct real estate, they may complement direct holdings over longer investment periods due to their partial overlap with equity market characteristics. In the mixed-asset portfolio of Japan, Hoesli et al. (2022) find strong risk-adjusted performance and diversification benefits from non-listed real estate funds. In the context of a global mixed-asset portfolio, Günther et al. (2022) show that once Eurobonds are incorporated, they dominate open-end real estate funds, resulting in an almost negligible optimal allocation to the latter.

Although U.S. pension funds have increased their real estate holdings, their current allocations remain roughly half of the levels recommended in academic studies. This discrepancy can be explained by several factors, including data limitations, the inherent features of real estate such as high transaction costs, heterogeneity, differences in investor risk preferences and differences of modelling. As an illustration, most evidence on optimal real estate allocation in mixed-asset portfolios draws on modern portfolio theory (Markowitz, 1952), which relies on short-term return data and assumes independently and identically distributed (i.i.d.) over time and frictionless markets. Under these assumptions, short- and long-term investors would adopt the same asset allocation (Merton, 1969; Samuelson, 1969). However, these conditions rarely hold for direct real estate, which is illiquid, costly to trade, and exhibits return persistence. To address this, Campbell and Viceira (2005) propose a horizon-dependent allocation model using a vector autoregressive framework. This has been applied and extended in real estate research by MacKinnon and Zaman (2009), Rehring (2012), Pagliari (2017), and more recently Delfim and Hoesli (2019), who examine different real estate types in US mixed-asset portfolios. Overall, these studies that have addressed this issue still find recommended allocations higher than those observed in practice.

While the conventional approach assumes that investors are concerned with the mean and variance of returns, institutional investors such as pension funds and insurance companies must ensure that future liabilities can be met sustainably. Therefore, an ALM framework is more appropriate for certain types of institutional investors. Within the ALM framework, Chun et al. (2000) find that the suggested allocation to listed real estate is around 10.5% in the US market for the global minimum-surplus variance portfolio of pension funds. Craft (2001) extends by considering both public and private real estate investments using a similar surplus optimisation, finding lower REIT allocations than those reported by Chun et al. (2000). In his study, REITs account for about 4.7% of the minimum-variance portfolio, and their share declines as portfolios become riskier along the efficient frontier. However, since allocations to private real estate fall even more sharply, the composition of real estate holdings increasingly shifts toward REITs in higher-risk portfolios. In the UK market, Key and Marcato (2007) illustrate that applying an ALM approach leads to a lower recommended allocation to direct real estate investment than the classic mean-variance portfolio—closer to the actual allocations observed among institutional investors. Overall, these studies all indicate that under the ALM framework, institutional investors tend to favour assets that are highly correlated with their liabilities.

Brounen et al. (2010) analyse the effect of fair value accounting for pension liabilities, introduced by the 2006 U.S. Pension Protection Act, on portfolio choices within an ALM framework, based on the single-period surplus optimisation investment framework of Sharpe and Tint (1990). They find that portfolio composition varies depending on the definition of liability returns, with some allocations to direct real estate but limited or no role for listed real estate in pension fund portfolios. Johner and Hoesli (2025) advance this by investigating portfolio composition across sectors and market types in a liability-driven portfolio for US pension funds. Using a non-parametric surplus optimisation framework, they show that direct real estate allocations are generally lower when liabilities are considered than in the asset-only case. Interestingly, they note that for low-risk portfolios, plans with longer liability durations allocate more to real estate, while for high-risk strategies, plans with moderate durations allocate highest real estate. Our study extends this strand of literature by focusing on the largest institutional investors in Europe—insurance companies—and by providing a comprehensive analysis of three distinct routes of real estate investment within their portfolios.

3. Research Motivation

Our work contributes to the existing literature in three dimensions. First, we investigate whether and how listed real estate can improve insurance companies' portfolios. As the existing studies focus on pension funds, we focus on insurance companies which represent the largest institutional investors in Europe. In 2024, total assets under management⁴ by European (re)insurers are approximately €9.6 trillion, compared to €2.6 trillion managed by pension funds. A key challenge for institutional investors is ensuring their assets can meet future liabilities. Our work directly addresses this by ALM framework, thereby bridging a significant gap in both the current real estate and portfolio modelling literature. Unlike previous studies, we integrate the crucial liability element and incorporate the regulation imposed by Solvency II, offering a more comprehensive and practically relevant approach to investment strategy for insurers.

Second, motivated by the US evidence presented in Delfim and Hoesli (2019), our European analysis examines how the role of listed real estate interacts with, and may be displaced by, other forms of real estate investment within a mixed-asset portfolio, thereby extending the UK evidence provided by Rehring (2012). While prior literature has mainly emphasised the theoretically optimal allocation to listed real estate within mixed-asset portfolios, we address this gap by comparing recommended allocations with the actual holdings of insurance companies. This comparison provides more actionable investment and policy-relevant insights. The contribution is particularly important, as existing ALM studies on real estate for institutional investors do not provide a systematic review of how different types of real estate—listed, unlisted, and direct—compete with or complement one another within mixed-asset portfolios.

Finally, we examine the impact of the EU's Solvency II regulations on insurers' allocation to listed real estate. Introduced in 2016, Solvency II requires insurance companies to hold sufficient capital to meet obligations in the event of losses. Under these rules, the capital risk weighting for listed real estate is set at 39%, equivalent to equities, while direct real estate is assigned to a lower weighting of 25% reflecting its perceived lower risk. However, empirical research suggests that while listed real estate behaves similarly to equities in the short term, it mirrors the performance of direct

⁴ According to EIOPA (2024).

real estate over the long term. Given that real estate is typically a long-term investment, there is limited justification for treating listed and direct real estate differently in terms of capital requirements. Against this backdrop, we examine the effect of the LTE treatment introduced under the 2019 Solvency II regulatory amendment, under which eligible LTE investments, including listed real estate, benefit from a reduced capital requirement of 22%, compared with 39% under the standard equity treatment. Our analysis assesses how this regulatory change affects optimal allocations and portfolio performance within an ALM framework.

4. Methodology

4.1 Asset Liability Modelling

The mean-variance methodology, also known as the asset-only approach, allows portfolio diversification and identifies the set of efficient portfolios that optimise expected returns while minimising return variance. However, investors' objectives often differ in practice. Specifically, insurers seek to maximise their surplus while managing liability risk and complying with regulatory constraints.

Following Brounen et al. (2010), we adopt the framework of Sharpe and Tint (1990), which emphasises maximising the risk-adjusted surplus while incorporating liability hedge credits. Unlike standard approaches, which often impose an all-or-nothing treatment of liabilities, this model allows hedging credits to assign either partial or full weight to liabilities. This flexibility enables investors to optimise portfolio returns or surplus while accounting for varying degrees of liability exposure, rather than being constrained to extreme positions.

Consistent with Sharpe and Tint (1990), we adopt the single-period portfolio surplus optimisation model, based on the logarithmic utility function and investor constant risk aversion assumption frequently utilised in the literature. We use A and L to represent the asset and liability (L/A as reverse funding ratio), k as the liability multiplier, and tildes represent uncertain quantities. For purposes of decision making, the surplus under uncertainty is shown as:

$$\tilde{Z} = \tilde{R}_A - k \frac{L}{A} \tilde{R}_L \quad (1)$$

Thus, surplus optimisation can be converted as utility maximisation of

$$\max \varphi = \text{Expected}(\tilde{Z}) - \text{var}(\tilde{Z})/\lambda \quad (2)$$

Or simplified as:

$$\max[\text{Expected Return} - \text{Risk Penalty} + \text{Liability Hedge Credit}]$$

$$\max \left[\tilde{R}_A - \frac{\text{var}(\tilde{R}_A)}{\lambda} + LHC_A \right] \quad (3)$$

where λ represents a fund's risk tolerance.

$$LHC_A = \sum_i w_i LHC_i \quad (4)$$

$$LHC_i = 2 \frac{k}{\lambda} \frac{L}{A} Cov(\hat{R}_i, \hat{R}_L) \quad (5)$$

where LHC indicates the liability hedge credit, the subscript i refers to any single asset, the subscript A refers to the entire portfolio, and K is a parameter specifying the relative importance assigned to liabilities, ranging between 0 and 1. A value of $K = 1$ reflects full emphasis on liabilities, whereas $K = 0$ corresponds to an asset-only optimisation. w_i denotes the portfolio weight of asset i . The formula incorporates the liability-hedging characteristics of assets, so that those with higher liability hedge credits receive greater weights in the ALM portfolio compared with a conventional mean-variance optimisation. The overall objective function retains the structure of a standard asset-only optimisation problem.

In addition to augmented ALM framework described above, we implement a second optimisation strategy of Key and Marcato (2007). This approach focuses on minimising the risk of a shortfall in assets against liabilities, rather than merely reducing the volatility of asset return for institutional investors.

$$\min_w \sigma_S^2 \text{ subject to } \sum_{i=1}^n w_i = 1 \text{ and } \sum_{i=1}^n w_i R_i = R_A \quad (6)$$

where σ_S^2 is the variance of surplus (i.e., portfolio return- liability growth), w_i denotes portfolio weights for each asset, and R_A is the target asset portfolio return. If an asset exhibits liability hedging capacity, the optimisation will typically assign it a higher weight within the portfolio. Moreover, for the maximum Sharpe ratio strategy, we define the Sharpe ratio as the surplus return in excess of the liability growth, divided by the standard deviation of surplus excess return.

$$\max_w \left[\frac{R_S}{\sigma_S} \right] \text{ subject to } \sum_{i=1}^n w_i = 1 \text{ and } \sum_{i=1}^n w_i R_i = R_A \quad (7)$$

Finally, to align our modelling with Solvency II capital requirements, we adjust portfolio weights to reflect the relevant capital charges: 25% for direct real estate, 39% for listed real estate (Type 1), 39% for equities (Type 1), 49% for unlisted real estate (Type 2), 0% for government bonds, and 10% for corporate bonds. Following the recent regulatory amendment, the capital charge for listed real estate is also modelled at its revised level of 22% from the perspective of LTE category. To ensure that the five-year average holding period requirement for LTE is satisfied, we complement the analysis with a five-year rolling-window sub-period analysis. We also ensure that the portfolio maintains a solvency ratio above 130%, together with a positive surplus.

4.2 Panel Regression

To further understand how insurance companies select listed real estate investments, we conduct a panel OLS regression modelling with both time- and country-fixed effects. The sample comprises listed real estate companies across Europe, including Austria, Belgium, Denmark, France, Germany, Ireland, Italy, Netherlands, Norway, Sweden and UK:

$$Inst_{i,t} = \gamma_0 + \gamma_1 Char_{i,t-1} + \alpha D_{2016} + \beta (D_{2016} * Size_{i,t-1}) + c_i + y_t + \varepsilon_{i,t} \quad (8)$$

where $Inst_{i,t}$ is the logarithm of total investment by insurance companies in company i at time t ; $Char_{i,t-1}$ is a vector of company characteristic variables from the last period $t-1$, such as company size, revenue and leverage; D_{2016} is the year dummy to capture potential impact of Solvency II implemented in 2016 and $D_{2016} * Size_{i,t-1}$ is the interaction term where size is our key variable of interest related to liquidity.

Country dummies (c_i) allow the intercept to vary across regions, while year dummies (y_t) allow the intercept to differ across time periods. The country fixed effect can control time-invariant factors across regions, whereas the time fixed effects can control the common macroeconomic impact. We use the Thomson Reuters Business Classification (TRBC) industry classification from Refinitiv, which includes commercial REITs, diversified REITs, real estate rental, development & operations, real estate services, residential REITs and specialised REITs. There are 301 listed real estate companies across these 11 countries during 1997 to 2024.

5. Data Analysis

Consistent with the UK evidence presented by Rehring (2012), the major asset classes considered in our analysis include bonds, direct real estate, equities, and T-bills. To further investigate the role of different types of real estate within a mixed-asset portfolio, we expand by including listed and unlisted real estate in the analysis. The sample period spans Q1 2008 to Q4 2024, as the earliest available data on our additional real estate investment sourced from MSCI, dates back to 2008. The specific quarterly total market return proxy and the sources for each asset class are detailed in the following table.

Table 1. Data sources

Asset	Proxy	Source
Equities	FTSE developed Europe all cap index	DataStream
Cash	Bloomberg Euro treasury bills index	Bloomberg
Government bonds	FTSE Eurozone government bond index	DataStream
Corporate bonds	Bloomberg Barclays Pan-Euro aggregate corporate index	Bloomberg
Direct real estate	MSCI Pan Europe all properties total return index	MSCI
Listed real estate	FTSE EPRA Nareit developed Europe index	EPRA
Unlisted real estate	MSCI Pan-European quarterly property fund index	MSCI

Table 2 summarises the pan-European statistics across asset classes. Among the three real estate investment routes, before correcting for appraisal smoothing, unlisted real estate appears most attractive, combining the relatively higher return with the lowest risk. However, because direct and unlisted real estate returns are appraisal-based series, they are subject to smoothing bias, which is evident in their return characteristics – notably the low standard deviations of 2.13 for direct real estate and 2.00 for unlisted real estate, together with high first-order autocorrelations of 0.76 and 0.73, respectively.

To address this issue, we apply the conventional de-smoothing procedure using a first-order autoregressive filter (e.g., Geltner, 1993), which mitigates the effects of appraisal smoothing. As shown in Table 2, this adjustment results in lower autocorrelation and higher standard deviation for both de-smoothed direct and unlisted real estate returns, thereby improving their comparability with transaction-based series and being used in our portfolio modelling.

Overall equity markets generate the highest average returns, whereas bonds and bills, as expected, offer the lowest average returns and the lowest risk. In terms of skewness, although both direct and unlisted real estate have lower standard deviations, their skewness values are negative and markedly lower than those of listed real estate and other assets. This indicates a left-skewed distribution and a higher probability of negative outcomes than implied by a normal distribution. In addition, these assets also exhibit relatively higher positive kurtosis values than listed real estate and other asset classes, suggesting a greater likelihood of extreme events than a normal distribution would predict.

Table 2. Summary statistics across asset classes

	Direct RE	Unlisted RE	Direct RE -Des	Unlisted RE-Des	Listed RE	Equities	Govt bonds	Corp bonds	Cash
Mean	1.25%	1.30%	1.40%	1.45%	1.32%	1.73%	0.64%	0.66%	0.18%
SD	2.13%	2.00%	5.84%	5.12%	10.77%	8.51%	2.75%	2.49%	0.36%
Max	4.61%	4.62%	17.14%	13.45%	29.66%	17.73%	7.08%	6.89%	1.23%
Min	-6.63%	-6.83%	-21.27%	-19.29%	-34.21%	-24.67%	-7.29%	-7.36%	-0.31%
Skewness	-1.73	-1.40	-1.64	-1.57	-0.67	-0.82	-0.48	-0.80	1.25
Kurtosis	3.97	3.47	5.78	4.62	1.94	0.96	0.46	1.87	0.85
Autocorrelation	0.76	0.73	0.12	0.06	0.11	0.01	0.16	0.33	0.89

Table 3 reports correlations among investment returns across European asset classes. Direct real estate shows the strongest correlation with unlisted real estate, which can be partly attributed to their common trading in the private market. Interestingly, their correlation with equities exceeds that with listed real estate, although the difference between the correlations of unlisted real estate with listed real estate and equities is small. Equities exhibit negative correlations with both government and corporate bonds, whereas listed real estate show a positive relationship with these assets. Taken together, these findings highlight the hybrid nature of listed real estate and suggest their potential role as distinctive diversifiers within mixed-asset portfolios.

Table 3. Correlation across asset classes

	Direct RE -Des	Unlisted RE-Des	Listed RE	Equities	Govt bonds	Corp bonds	Cash
Direct RE-Des	1.00						
Unlisted RE-Des	0.91	1.00					
Listed RE	0.28	0.25	1.00				
Equities	0.40	0.26	0.13	1.00			
Govt bonds	-0.01	0.01	0.32	-0.05	1.00		
Corp bonds	0.11	0.15	0.50	-0.08	0.92	1.00	
Cash	-0.18	-0.12	-0.10	-0.20	0.33	0.31	1.00

6. Portfolio Analysis

6.1 Modern Portfolio Theory

We undertake a portfolio optimisation exercise applying Modern Portfolio Theory (MPT), or the asset-only approach, to a set of key asset classes: direct real estate, listed real estate, unlisted real estate, equities, and corporate and government bonds. Figure 3 presents the efficient frontier, and Figure 4 shows the corresponding asset weightings along this frontier.

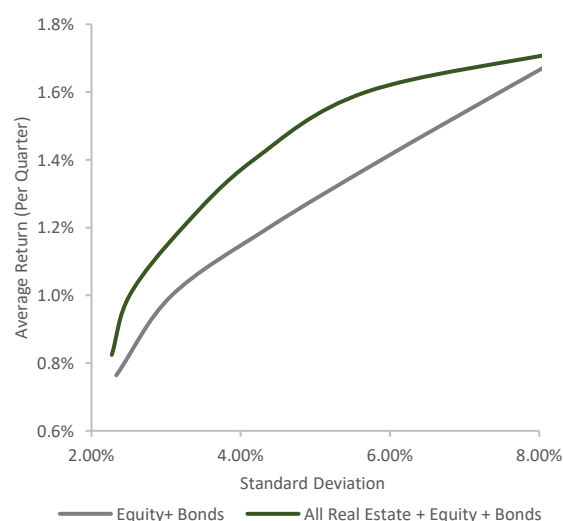
Our analysis begins with a base portfolio composed of equities and bonds, and compares it with portfolios in which each real estate investment route is added separately—treating them as substitutes—to assess the diversification benefits. Comparing Figures 3B, 3C and 3D, it is logical to think that each real estate investment route provides diversification benefits, as the efficient frontier shifts to the left in all cases. In this setting, in terms of short term returns, unlisted real estate and direct real estate offer relatively greater diversification benefits than listed real estate.

Examining the real estate asset class in isolation, our European results are consistent with prior literature, which suggests that real estate plays a role in the mixed-asset portfolios. For example, Rehring (2012) finds that commercial real estate is a good diversifier that enhances the efficient frontier in the UK, while Lee and Stevenson (2005) report that US REITs provide both return enhancement and risk reduction benefits, although the magnitude of these effects can vary over time.

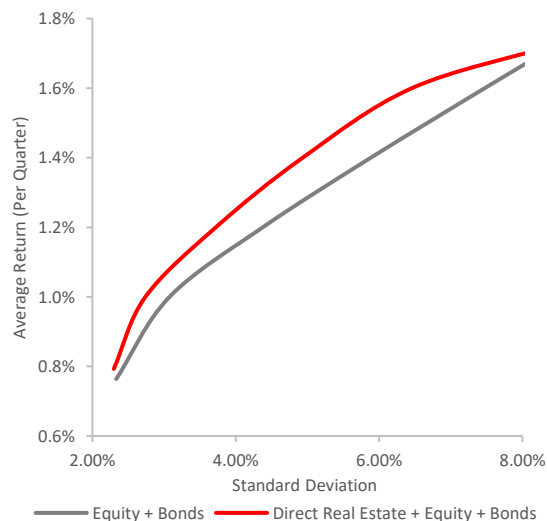
Next, we consider adding all real estate asset types to the mixed-asset portfolios, treating them as complementary assets rather than substitutes. This approach is more representative of insurers, which typically hold a variety of real estate assets. As an illustration, for the global minimum variance portfolio—yielding an average quarterly return of 0.82% and a standard deviation of 2.27%—the optimal allocation comprises around 11% unlisted real estate, 7% equities, 7% government bonds, and 74% corporate bonds, as shown in Figure 4a. Moving along the efficient frontier to target a higher expected return of 1.4% per quarter, the allocation changes markedly: unlisted real estate rises to 58%, listed real estate to 3%, equities to 24%, and government bonds to 14%. While Figure 4a suggests a relatively limited allocation to listed real estate when all real estate types are included together, it indicates a potential contribution—particularly around the middle of the efficient frontier.

Figure 3. Efficient frontier based on selected asset classes

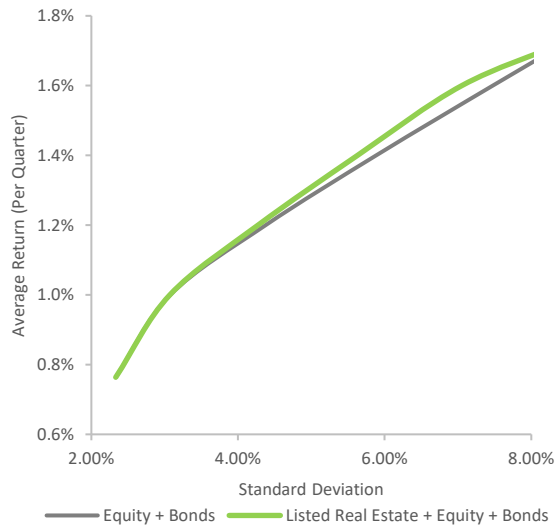
A. All types of real estate



B. Direct real estate



C. Listed real estate



D. Unlisted real estate

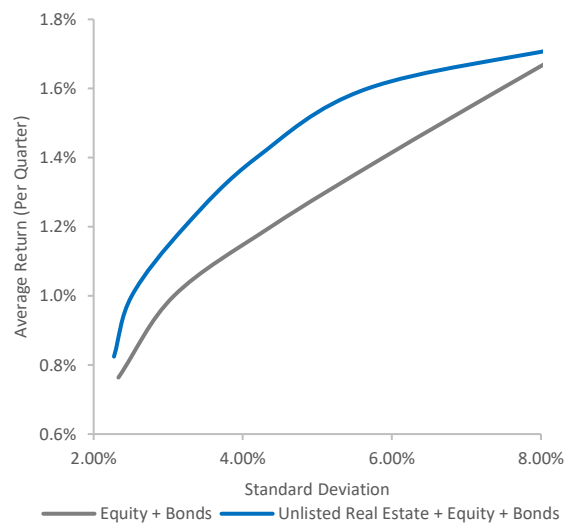
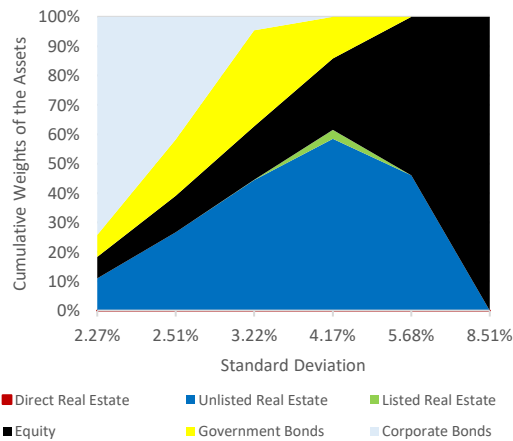
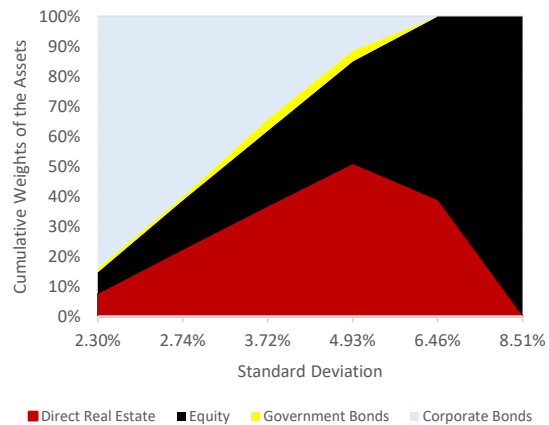


Figure 4. Allocations along the efficient frontier

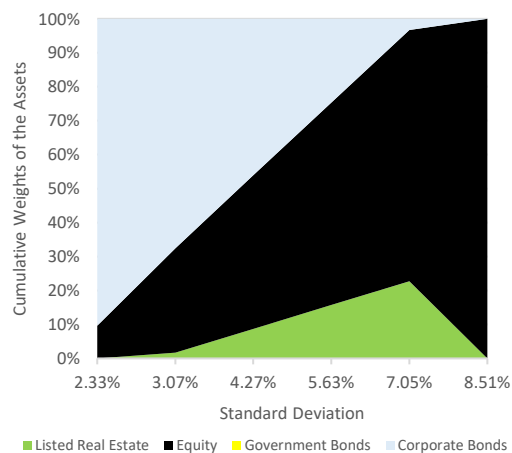
A. All types of real estate



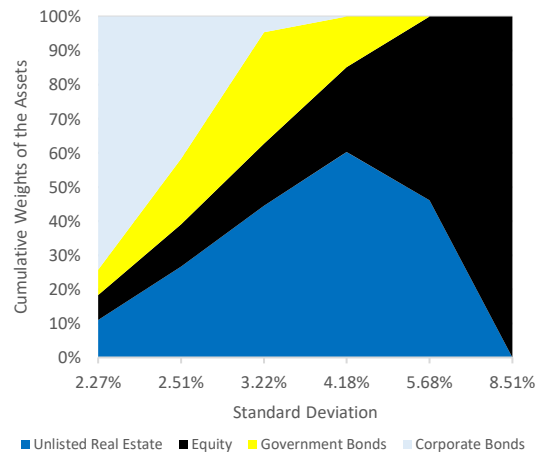
B. Direct real estate



C. Listed real Estate



D. Unlisted real estate



Comparing our results with the existing literature on European listed real estate in mixed-asset portfolios, our findings recommend a relatively lower allocation to listed real estate when all types of real estate are considered. Lizieri et al. (2022) demonstrate that, under an uncertainty-aversion approach with a 95% confidence interval, the average optimal allocation to listed real estate is 21%. However, this approach ignores other types of real estate and focuses solely on listed real estate within mixed-asset portfolios. Barton and Varanasi (2024) extend this analysis by incorporating both listed and direct real estate in mixed-asset portfolios. Their results suggest lower allocations to listed real estate of 6%, 10%, and 10% for low-, medium-, and high-risk portfolios, respectively. This study advances this strand of literature by considering direct, listed, and unlisted real estate, and therefore finds an even lower allocation to listed real estate. In particular, the results highlight its unique hybrid role, contributing most strongly to optimal portfolios located around the middle of the efficient frontier.

Our Markowitz efficient frontier optimisation follows Muller and Muller (2024). Consistent with their US evidence, our European results show that both listed real estate and unlisted real estate play a role in mixed-asset portfolios, with unlisted real estate dominating along much of the efficient frontier. We extend Muller and Muller (2024) by incorporating a direct real estate asset explicitly (rather than proxying it via an unlisted real estate index). The conclusion remains the same: for higher return targets under risk minimisation, unlisted real estate emerges as the preferred asset. Altogether, this aligns with our earlier market evidence that insurance companies have a strong and growing appetite for unlisted real estate, while allocations to direct real estate are in decline. Although our unconstrained optimisation—treating all real estate assets as complements—finds some limitations for listed real estate, this does not imply a lack of investment value. Given that insurers must also hedge against liabilities, incorporating liability-driven constraints and other real-world considerations into the optimisation process may produce allocations to listed real estate that better reflect observed practice.

6.2 Asset Liability Modelling

While much of the literature examines the role of real estate in mixed-asset portfolios through mean-variance optimisation (i.e., minimising portfolio risk for a given level of return), this framework may be less suited to institutional investors such as insurance companies and pension funds. For these investors, optimising portfolios solely on the basis of return-volatility trade-offs can entail a substantial risk of shortfall relative to liabilities. Consequently, an emerging body of research has advocated shifting from traditional MPT-based approaches towards models that explicitly account for the risk of asset-liability mismatches. In this context, ALM has increasingly been applied to real estate investment, with the objective of aligning asset allocation decisions to liability structures rather than simply minimising portfolio variance (e.g., Brounen et al., 2010; Chun et al., 2000; Johner & Hoesli, 2025; Key & Marcato, 2007).

Key and Marcato's (2007) optimisation target focuses on minimising the risk of a shortfall in assets against liabilities rather than simply reducing asset value volatility. Analysing portfolios comprising direct real estate, equities, cash, gilts, and index-linked gilts, they find that the suggested allocation to direct real estate ranges from 1% to 40%, depending on the scenario. Overall, their results indicate a lower allocation to direct real estate once liabilities are taken into account, bringing the outcome closer to the actual direct real estate allocations observed in mixed-asset pension fund portfolios.

Applying the surplus optimisation investment framework of Sharpe and Tint (1990), Brounen et al. (2010) examine the liability-hedging properties of both direct and indirect real estate for pension funds. Their findings indicate that optimal portfolio composition is sensitive to the definition of liability returns. Within the ALM framework, they identify modestly higher allocations to both direct and listed real estate compared with a traditional mean-variance framework based solely on assets. Specifically, in an ALM setting comprising four asset classes—direct real estate, listed real estate, equities, and fixed income—the recommended allocation to direct real estate ranges from 11.46% to 25.23%, while the allocation to listed real estate ranges from 0.40% to 12.51%, contingent upon the liability proxies and portfolio objectives.

Notably, nearly all of the existing studies have examined the role of real estate within an ALM framework, focusing on its implications for pension funds. Our study extends by focusing on insurance companies. We adopt a fundamental ALM framework but adapt it to the regulatory environment under Solvency II, incorporating a liability proxy that more accurately reflects the risk profile and capital requirements of insurers. A key methodological challenge in ALM research is limited availability of liability index data, so most studies rely on proxies. For example, Key and Marcato (2007) use national income per capita and index-linked gilts to proxy liabilities for pension funds, implicitly assuming that these proxies move in line with liability performance. Similarly, Hoevenaars et al. (2008) assume that changes in liabilities follow the returns of a long-term inflation-adjusted bond. In line with the literature, we construct liability proxies tailored to insurance companies. A key advantage of our study is the availability of actuarial liability data for the period 2016Q4–2024Q4. This enables a subsample ALM analysis using three liability measures: total liabilities, technical provisions, and duration-matched benchmark.

Technical provisions are actuarially determined reserves that insurers must hold to cover expected future policyholder claims and associated risks. These provisions are calculated separately across five main types of business: index-linked and unit linked, nonlife (excluding health), health (similar to non-life), health (similar to life), and life (excluding health and index-linked and unit-linked). The total liabilities of an insurer comprise its technical provisions and other liabilities (sourced from EIOPA), such as debt, financial commitments, and deposits. We also construct a duration-matched portfolio to replicate the duration characteristics of insurers' liabilities within the ALM framework.

To ensure that our modelling reflects the capital requirements of the Solvency II framework, portfolio weights are explicitly adjusted for the corresponding capital charges: 25% for direct real estate, 39% for listed real estate (Type 1), 39% for equities (Type 1), 49% for unlisted real estate (Type 2), 0% for government bonds, and 10% for corporate bonds.⁵ We further ensure that the resulting solvency ratio remains above 130%, with a positive surplus.

Table 4 presents the results of ALM, starting with technical provisions as a proxy for the liabilities. Panel A applies the approach of Key and Marcato (2007), which focuses on tracking error by minimising the risk of funding surplus, while Panel B augments the ALM with liability-hedging credits and mean-variance optimisation (MVP). Extending their framework, we incorporate three real estate investment routes alongside Solvency II regulations. Both approaches yield broadly similar results, with ALM portfolios exhibiting a relatively high allocation to cash, reflecting the capital requirements embedded in the Solvency II framework used in the modelling.

Based on the conventional approach of ALM, the suggested allocation to listed real estate is about 11.78% in the global minimum variance portfolio (i.e., the portfolio of the lowest risk). In the case of unlisted real estate, the allocation is 34.61%, with no allocation to direct real estate. The result is similar to the augmented ALM. Recognising that insurers aim to maximise surplus based on the risk

⁵ The capital charge for corporate bonds is around 5–20%, depends on rating/duration. Here, we consider a neutral value of 10%. We also consider an average value of 12.5% as well, and the results remain similar.

they bear, we also consider an optimal risky portfolio, defined as maximising the risk-adjusted surplus. Again, both ALM approaches deliver similar results and recommend a higher allocation to listed real estate. Overall, these findings indicate that listed real estate provides strong liability-hedging benefits, which help to explain its role in an ALM setting.

Table 4. ALM: technical provisions

	Weights									Surplus Sharpe ratio
	Direct RE	Unlisted RE	Listed RE	Equity	Govt bond	Corp bond	Cash	Portfolio return	Portfolio S.D.	
Panel A: ALM										
1. Min surplus standard deviation	0.00%	34.61%	11.78%	6.07%	23.62%	0.00%	23.92%	0.70%	2.84%	16.20%
2. Max risk- adj-surplus	0.00%	24.68%	11.94%	33.55%	0.00%	0.00%	29.83%	1.27%	3.54%	25.72%
Panel B: Augmented ALM with LHC and MVP										
1. Min surplus standard deviation	0.00%	33.14%	12.46%	5.71%	25.37%	0.00%	23.32%	0.41%	2.85%	16.93%
2. Max risk- adj-surplus	0.00%	23.52%	15.25%	31.49%	0.00%	0.00%	29.75%	1.25%	3.50%	26.55%

Note: For the liability hedge credit in augmented ALM, we adopt a common assumption, setting $k=1$, $\lambda=5$, and $L/A=0.75$. The relevant capital requirement for each asset and solvency ratio above 130 is imposed in the modelling.

When comparing results with the asset-only portfolio under modern portfolio theory, we previously found limited role for listed real estate within mixed-asset allocations. By contrast, within the ALM framework, listed real estate assumes a much more prominent role. Although listed real estate might not consistently exceed the risk-adjusted performance of direct or unlisted, its performance is broadly comparable. Fundamentally, listed real estate offers distinct advantages, including enhanced liquidity, lower transaction costs, and greater transparency, thereby supporting more efficient portfolio rebalancing and risk management. Accordingly, listed real estate constitutes a complementary form of direct real estate exposure within institutional portfolios, particularly in liability-driven investment settings where flexibility and market responsiveness are valued.

A natural question arises: why does listed real estate offers such strong hedging properties? Liabilities are typically expressed in nominal terms and tend to move in line with inflation. Consequently, assets that provide effective inflation hedging often also serve as good liability hedges. While real estate generally provides an effective hedge against inflation through two main channels—lease payments (income return) and land values and construction costs (capital gain return), listed real estate can further enhance liability-hedging effectiveness by offering a more dynamic form of inflation protection than direct or unlisted real estate. Listed real estate companies actively manage their portfolios through acquisitions, disposals, redevelopments, and maintenance capital expenditure, enabling them to continuously rebalance towards high-quality assets and strong market segments. This active management not only reflects sound corporate governance but also strengthens the inflation-hedging capacity of income-driven strategies along with high asset rotation and robust capital growth.

Supporting this interpretation, Muckenhaupt et al. (2025) demonstrate that listed real estate provides meaningful protection against inflation, particularly expected inflation and over the long run, and that its hedging benefits exceed those of equities. Their inflation-hedging portfolio optimisation approach further indicates that listed real estate should hold a prominent position in investors' allocations. Notably, their inflation-hedging framework shifts the traditional investment objective away from variance minimisation as a measure of risk, instead focusing on minimising downside inflation risk—an approach partially similar to our ALM framework, which emphasises ensuring that liabilities can be sustainably met.

7. Robustness Check: Alternative Proxy for Liability

7.1 Total Liability

As the results may be sensitive to the choice of liability proxy, we also consider an alternative measure—total liabilities. Table 5 presents the corresponding results, showing that the allocation to listed real estate ranges from 8.51% to 11.62%, depending on the model specification and the portfolio of interest (or degree of investor risk appetite). Consistent with earlier findings, we observe no role for direct real estate in either the global minimum variance portfolio or the optimal risky portfolio. By contrast, unlisted real estate continues to attract significant allocations, for instance, with 37.45% in the global minimum variance portfolio and 27.11% in the optimal risky portfolio, in the conventional ALM approach. The cash allocation remains similar to that reported in Table 4, reflecting the capital requirements incorporated into the modelling framework.

Table 5. ALM: total liability

Table 2: ALM total liability										
	Weights							Portfolio return	Portfolio S.D.	Surplus Sharpe ratio
	Direct RE	Unlisted RE	Listed RE	Equity	Govt bond	Corp bond	Cash			
Panel A: ALM										
1. Min surplus standard deviation	0.00%	37.45%	8.51%	5.30%	25.01%	0.00%	23.74%	0.71%	2.74%	22.12%
2. Max risk-adj-surplus	0.00%	27.11%	8.86%	34.02%	0.00%	0.00%	30.01%	1.30%	3.57%	33.51%
Panel B: Augmented ALM with LHC and MVP										
1. Min surplus standard deviation	0.00%	36.39%	9.10%	5.05%	26.12%	0.00%	23.35%	0.36%	2.53%	16.08%
2. Max risk-adj-surplus	0.00%	26.04%	11.62%	32.41%	0.00%	0.00%	29.93%	1.28%	3.50%	25.99%

Notes: For the liability hedge credit in augmented ALM, we adopt a common assumption, setting $k=1$, $\lambda=5$, and $L/A=0.75$. The relevant capital requirement for each asset and solvency ratio above 130 is imposed in the modelling.

7.2 Duration-Matched Portfolio

To mitigate the potential impact of duration mismatches on portfolio structure, we follow Brounen et al. (2010) and construct a duration-matched portfolio by combining two fixed-income securities, designed to replicate the characteristics of pension liabilities within the ALM framework. The duration of fixed-income securities is computed as:

$$D_{n,t} = \frac{1 - (1 + Y_{n,t})^{-n}}{Y_{n,t}}$$

(9)

where $Y_{n,t}$ represents the log annualised yield for n -year maturity of bond at time t .

The average duration of Eurozone government bonds with maturities of 7–10 years is approximately 8.95 years, whereas that of Pan-European Aggregate Corporate bonds is about 6.13 years. To determine the weighting factor (w) assigned to each fixed-income security in the duration-matched portfolio, we solve the following equation:

$$D_{L,t} = w * D_{8.95,t} + (1 - w) * D_{6.13,t}$$

(10)

$$w = \frac{D_{8.95,t} - D_{6.13,t}}{D_{L,t} - D_{6.13,t}}$$

(11)

where $D_{L,t}$ is the duration of insurers' liability, set at 8.72 years, corresponding to the average duration of technical provisions reported by EIOPA for insurance companies. $D_{8.95,t}$ is the duration set for government bond while $D_{6.13,t}$ is set for the corporate bonds.

Table 6 reports the ALM results using the new liability proxy with a duration-matched portfolio. The suggested allocation to listed real estate is approximately 6.51% and 6.69%, depending on the model specification for the global minimum variance portfolio. In the optimal risky portfolio, the allocation increases substantially ranging from 15.34% to 16.29%. The pattern and role of listed real estate within the ALM framework remain consistent with the previous results obtained using alternative liability proxies. Interestingly, in this setting, the role of unlisted real estate is more muted and can be reduced to a suggested allocation of 0%, depending on the model specification.

Table 6. ALM: duration matched portfolio

Table 3: ALM duration-matched portfolios										
	Weights							Portfolio return	Portfolio S.D.	Surplus Sharpe ratio
	Direct RE	Unlisted RE	Listed RE	Equity	Govt bond	Corp bond	Cash			
Panel A: ALM										
Min surplus standard deviation	19.26%	0.00%	6.69%	7.31%	56.46%	0.00%	10.28%	0.40%	2.61%	31.24%
Max risk-adj-surplus	24.98%	0.00%	16.29%	33.18%	0.00%	0.00%	25.54%	1.26%	3.70%	35.42%
Panel B: Augmented ALM with LHC and MVP										
Min surplus standard deviation	10.99%	6.57%	6.51%	7.22%	57.39%	0.00%	11.32%	0.41%	2.57%	33.44%
Max risk-adj-surplus	0.00%	24.28%	15.34%	30.57%	0.00%	0.00%	29.80%	1.24%	3.47%	36.85%

Notes: For the liability hedge credit in augmented ALM, we adopt a common assumption, setting $k=1$, $\lambda=5$, and $L/A=0.75$. The relevant capital requirement for each asset and solvency ratio above 130 is imposed in the modelling.

8. Summary of Liability Hedging Features

We next examine the liability-hedging ability across assets. If an asset provides an effective hedge against liabilities, it is expected to exhibit a stronger correlation with them. Table 7 reports these results. Compared with other risky assets (equities, direct real estate, and unlisted real estate), listed real estate consistently shows higher and positive correlations across the three liability proxies. Table 8 further presents the computed liability hedge credit for each asset class. Across all 12 scenarios (three liability proxies $\times$ four scenarios per proxy), listed real estate achieves the highest liability-hedging scores. These findings provide strong and consistent evidence of its liability-alignment properties and confirm the robustness of our earlier findings within the ALM framework.

Table 7. Asset correlation with liability

	Direct RE	Unlisted RE	Listed RE	Equity	Govt bond	Corp bond	Cash	Total liability	Technical provisions	Duration matched
Direct RE	1.00									
Unlisted RE	0.96	1.00								
Listed RE	0.15	0.27	1.00							
Equity	0.52	0.41	-0.13	1.00						
Govt bond	0.23	0.21	0.54	0.05	1.00					
Corp bond	0.22	0.24	0.67	-0.02	0.96	1.00				
Cash	0.07	0.05	0.23	0.08	0.35	0.40	1.00			
Total liability	0.30	0.34	0.63	-0.11	0.81	0.84	0.26	1.00		
Technical provisions	0.30	0.35	0.70	-0.09	0.84	0.88	0.31	0.99	1.00	
Duration matched	0.25	0.23	0.57	0.05	0.99	0.97	0.36	0.81	0.84	1.00

Table 8. Liability hedge credit

	Direct RE	Unlisted RE	Listed RE	Equities	Govt bond	Corp bond	Cash	K	λ	L/A
Panel A: total liability										
	0.009%	0.011%	0.047%	-0.007%	0.017%	0.017%	0.001%	1	5	0.75
	0.013%	0.015%	0.062%	-0.009%	0.023%	0.023%	0.001%	1	5	1
	0.005%	0.006%	0.023%	-0.003%	0.009%	0.009%	0.000%	0.5	5	0.75
	0.002%	0.003%	0.012%	-0.002%	0.004%	0.004%	0.000%	1	20	0.75
Panel B: technical provisions										
	0.011%	0.013%	0.057%	-0.006%	0.020%	0.020%	0.001%	1	5	0.75
	0.014%	0.017%	0.076%	-0.007%	0.026%	0.027%	0.001%	1	5	1
	0.005%	0.006%	0.029%	-0.003%	0.010%	0.010%	0.001%	0.5	5	0.75
	0.003%	0.003%	0.014%	-0.001%	0.005%	0.005%	0.000%	1	20	0.75
Panel C: duration-matched										
	0.009%	0.009%	0.049%	0.003%	0.025%	0.023%	0.001%	1	5	0.75
	0.012%	0.012%	0.066%	0.004%	0.033%	0.031%	0.002%	1	5	1
	0.004%	0.004%	0.025%	0.002%	0.012%	0.012%	0.001%	0.5	5	0.75
	0.002%	0.002%	0.012%	0.001%	0.006%	0.006%	0.000%	1	20	0.75

Note: See equation (5) for model specification for computing this score. Standard assumptions are applied to the parameters.

9. Effective Regulatory Change

The EU's Solvency II framework listed real estate was historically treated as standard equities, with a capital risk weighting of 39%. This contrasts with direct real estate, which carries a lower requirement of 25% owing to its perceived lower risk. However, existing research has indicated that while listed real estate behaves like equities in the short term, its performance converges with direct real estate in the long term. For instance, MSCI (2017) demonstrates that listed real estate and direct real estate exhibit strong alignment over multi-year horizons, such as three- and five-year periods.

Against this backdrop, we examine the regulatory amendment implemented in 2019, following the proposals by the European insurance industry to introduce a new risk sub-module to reduce the capital requirement for LTE including listed real estate from 39% to 22%.

To investigate the implications of this change, we relax the capital requirement with results, using a more robust ALM approach, reported in Table 9. In contrast to previous result of 39% capital requirement in Table 4, we find that the suggested allocation to listed real estate in the optimal risky portfolio has slightly increased by 1.27%, with an improvement on surplus Sharpe ratio as well.

Although applying the capital charge from 39% to 22% improves the regulatory treatment of listed real estate, the resulting allocation shift remains moderate. This is because portfolio optimisation in an asset-liability framework is primarily driven by risk-return characteristics and liability-hedging effectiveness rather than regulatory capital charge alone. As a result, the asset already receives a meaningful allocation in the optimal portfolio. Relaxing the capital constraint therefore improves its attractiveness marginally, leading to a moderate rather than dramatic increase in allocation.

While listed real estate exhibits return characteristics distinct from broader equities, our modelling shows that more favourable capital treatment increases its allocation, particularly when combined with its liability-hedging benefits. Under the revised framework, the recommended allocation to listed real estate ranges from 12.39% to 16.52%, depending on insurers' risk appetite, which is substantially higher than the observed allocation of 1.51%.⁶ This suggests that, within a liability-driven investment framework, insurers could enhance their exposure to listed real estate.

Table 9. ALM with 22% capital requirement for listed real estate

Table 3: ALM with 22% Capital Requirement for Listed Real Estate										
	Weights							Portfolio return	Portfolio S.D.	Surplus Sharpe ratio
	Direct RE	Unlisted RE	Listed RE	Equity	Govt bond	Corp bond	Cash			
Augmented ALM with LHC and MVP										
1. Min surplus standard deviation	0.00%	33.25%	12.39%	5.66%	27.47%	0.00%	21.23%	0.70%	2.88%	16.75%
2. Max risk-adj-surplus	0.00%	23.65%	16.52%	32.09%	0.00%	0.00%	27.74%	0.10%	0.39%	26.90%

Notes: For the liability hedge credit in augmented ALM, we adopt a common assumption, setting $k=1$, $\lambda=5$, and $L/A=0.75$. The relevant capital requirement for each asset and solvency ratio above 130 is imposed in the modelling. The liability proxy in this case is technical provisions.

⁶ This is based on our calculation from the data collected from EIOPA (2025), along with Figures 1 and 2.

Previously, our empirical exercise in Table 9 is unconditional without strictly considering the holding period of 5 years to qualify for LTE classification. Therefore, Table 10 addresses this and presents the subperiod results under both the previous (39%) and effective (22%) capital requirements, over 5 years with one year steps. While the results vary across different periods, the overall conclusions remain mostly consistent. First, the effective change in capital requirements has less impact on the allocation of listed real estate within the global minimum variance portfolio, but it does influence the optimal risky portfolio. This underscores the role of listed real estate in enhancing the risk-adjusted surplus for insurers. Second, in most scenarios there is an increased allocation to listed real estate, although the effect is less clear in the final periods of rolling window, likely reflecting market distortions associated with major shocks, including the COVID-19 pandemic and the Russia-Ukraine conflict.

Table 10. Five-year subperiod rolling window

	Weights							Portfolio return	Portfolio S.D.	Surplus Sharpe ratio
	Direct RE	Unlisted RE	Listed RE	Equity	Govt bond	Corp bond	Cash			
Panel A: 2016-2021										
1. GMV (39% in listed real estate)	6.75%	45.31%	10.22%	0.00%	9.83%	0.00%	27.88%	1.50%	1.64%	40.23%
2. Optimal risky (39% in listed real estate)	74.06%	0.00%	5.35%	0.00%	0.00%	0.00%	20.60%	1.95%	2.08%	46.19%
3. GMV (22% in listed real estate)	0.00%	53.37%	7.96%	0.00%	10.77%	0.00%	27.90%	1.483%	1.470%	40.46%
4. Optimal risky (22% in listed real estate)	72.11%	0.00%	8.08%	0.00%	0.00%	0.00%	19.81%	1.96%	2.19%	46.86%
Panel B: 2017-2022										
1. GMV (39% in listed real estate)	0.00%	22.31%	12.25%	8.68%	37.67%	0.00%	19.09%	0.04%	3.36%	1.78%
2. Optimal risky (39% in listed real estate)	0.00%	27.65%	0.00%	42.30%	0.00%	0.00%	30.05%	0.64%	4.87%	9.57%
3. GMV (22% in listed real estate)	0.00%	23.14%	10.26%	8.89%	15.78%	22.61%	19.32%	0.04%	3.30%	1.78%
4. Optimal risky (22% in listed real estate)	0.00%	27.65%	0.00%	42.30%	0.00%	0.00%	30.05%	0.64%	4.87%	9.57%

Panel C: 2018-2023										
1. GMV (39% in listed real estate)	0.00%	10.57%	13.80%	8.10%	53.82%	0.00%	13.72%	0.22%	3.45%	1.61%
2. Optimal risky (39% in listed real estate)	0.00%	0.00%	20.40%	51.55%	0.00%	0.00%	28.06%	1.05%	5.22%	14.29%
3. GMV (22% in listed real estate)	0.00%	11.01%	13.37%	8.25%	52.71%	2.81%	11.84%	0.22%	3.48%	1.61%
4. Optimal risky (22% in listed real estate)	0.00%	0.00%	22.21%	52.45%	0.00%	0.00%	25.34%	1.07%	5.37%	14.48%
Panel D: 2019-2024										
1. GMV (39% in listed real estate)	0.00%	41.94%	9.93%	10.49%	0.00%	8.30%	29.34%	0.64%	3.57%	18.78%
2. Optimal risky (39% in listed real estate)	0.00%	2.73%	10.02%	58.99%	0.00%	0.00%	28.25%	1.46%	5.43%	25.49%
3. GMV (22% in listed real estate)	0.00%	42.60%	9.18%	10.52%	0.00%	9.74%	27.97%	0.64%	3.58%	18.57%
4. Optimal risky (22% in listed real estate)	0.00%	2.89%	9.91%	60.14%	0.00%	0.00%	27.05%	1.48%	5.53%	25.48%

Notes: For the liability hedge credit in augmented ALM, we adopt a common assumption, setting $k=1$, $\lambda=5$, and $L/A=0.75$. The relevant capital requirement for each asset and solvency ratio above 130 is imposed in the modelling. The liability proxy in this case is technical provisions.

10. Drivers of Institutional Investment in Listed Real Estate

Beyond the role of listed real estate in insurers' asset allocations, we further examine the factors influencing institutional investors' decisions to allocate capital to listed real estate—focusing particularly on firm-level financial characteristics and macroeconomic conditions. Understanding these drivers is critical for listed real estate managers and investors seeking to attract institutional capital.

Han et al. (1998) observe that, after 1994, institutional investors allocated a greater share of their portfolios to REITs than to non-REIT stocks. Ciochetti et al. (2002) further note that institutional investors tend to take larger positions in REITs than in direct real estate, primarily due to liquidity considerations. Das et al. (2015) show that REIT allocations vary over time with economic conditions; for example, during the global financial crisis, institutional investors shifted capital from direct real estate to REITs. We extend this US-focused literature by incorporating evidence from European markets.

We focus on the eleven European countries with the largest real estate exposure and collect the shareholder information of each listed real estate company from Refinitiv database (Table 11). Figure 5 shows the total value of the listed real estate investments held by insurance companies in the samples of listed real estate companies. As illustrated, there is a growing demand for listed real estate investments in the long term. However, between 2009 and 2016, aggregate investment values remained broadly stable, albeit with some fluctuations. This period aligns with the formal adoption of Solvency II by the European Parliament and the Council of the European Union in 2009, and its implementation in 2016.

Notably, a marked increase in investment activity was observed following the onset of COVID-19 pandemic, potentially reflecting a heightened preference for space and direct real estate exposure, pursued through indirect vehicles. Although values declined significantly towards the end of the pandemic, appetite for listed real estate investments remains strong. Overall, the preliminary results align with US evidence from Das et al. (2015), which found that during periods of crisis, institutional investors reallocated capital from the illiquid private market to the more liquid listed real estate market—a flight to liquidity. Our European findings, particularly during the COVID-19 crisis, reveal a similar trend.

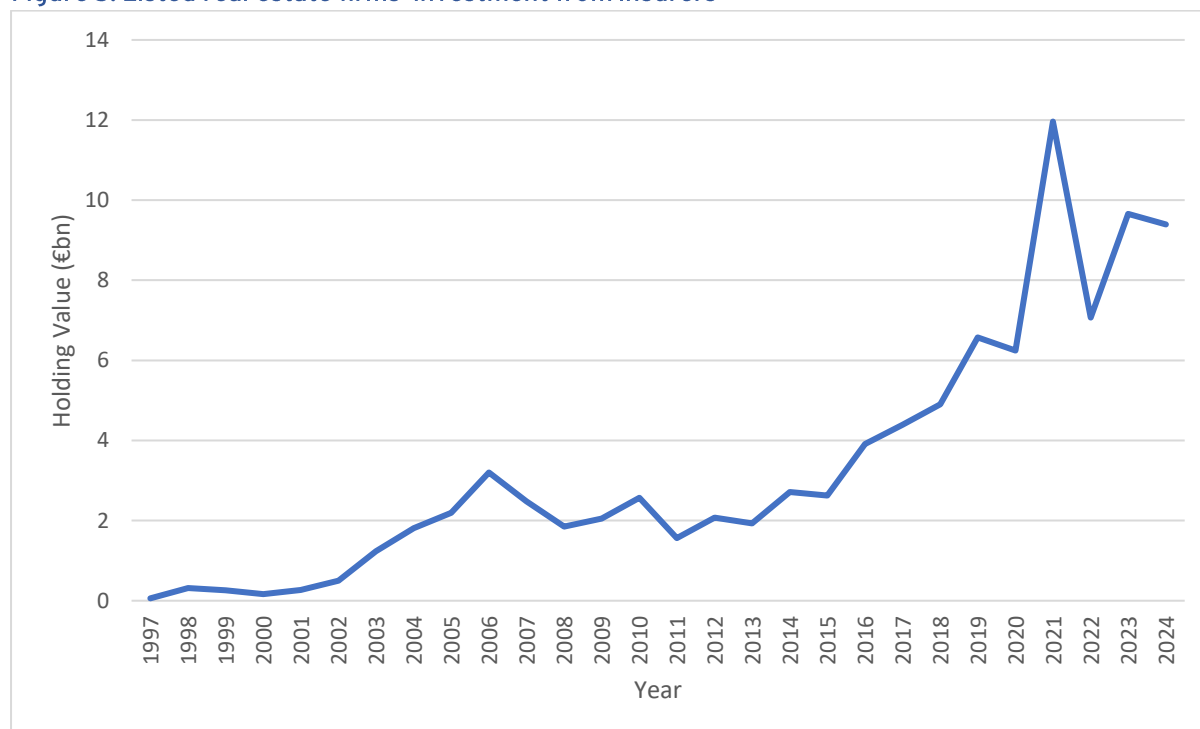
Table 11. Sample average market cap of real estate firms invested by insurance companies, 1997–2024

Country	Commercial REITs	Diversified REITs	Real estate rental, development & operations	Real estate services	Residential REITs	Specialised REITs
Austria	0	0	4.15	0	0	0
Belgium	7.09	0	5.85	0	0.60	7.16
Denmark	0	0	2.04	0	0	0
France	25.62	10.38	1.79	0.16	0	0.65
Germany	2.27	0	57.15	2.64	0	0
Ireland	0	0	0	0	0.57	0
Italy	0.66	0	0.07	0.09	0	0
Netherlands	3.78	0	6.26	0	0	0
Norway	0	0	31.46	0	0	0
Sweden	0	0	312.42	0	0	0
UK	18.81	12.82	4.62	3.60	4.16	6.31
Total	58.23	23.21	425.80	6.49	5.33	14.12

Notes: All values are reported in billions of euros. Data of listed real estate companies are sourced from Refinitiv. The TRBC industry classification for listed real estate companies include commercial REITs, diversified REITs, real estate rental, development & operations, real estate services, residential REITs and specialised REITs.

To analyse institutional investors' preferences for listed real estate, this study builds on the framework developed by Ciochetti et al. (2002). Their theoretical model assumes that institutional investors seek to manage risk for plan sponsors by aligning assets with liabilities, subject to liquidity considerations. Recognising differences in liquidity needs across investors, the model indicates that those facing tighter liquidity constraints are more likely to hold liquid assets such as REITs when wealth is limited, and gradually allocate to less liquid assets like private real estate as wealth grows. Their US-based empirical analysis also confirms that institutional investors show distinct preferences larger and more liquid REITs.

Figure 5. Listed real estate firms' investment from insurers



Notes: The figure displays the investment values from insurers in listed real estate firms across 11 countries. The data is collected from Refinitiv.

Table 12 investigates this issue from the perspective of insurance companies using panel OLS regression. Specifically, we regress insurance companies' investment in each listed real estate company on key firm-level characteristics—namely, firm size, revenues, and debt—while controlling for country and time fixed effects. Our results indicate that firm size is the most important determinant of listed real estate holdings by insurance companies. To account for the potential impact of Solvency II, implemented in 2016, we include a policy dummy. As shown in Models (1) and (2), the coefficient on the policy dummy is significantly negative, suggesting a temporary decline in listed real estate investments around the implementation period. However, the interaction between firm size and the policy dummy is statistically insignificant, implying that the selection of listed real estate based on firm size was not affected by the policy change. In Models (3) and (4), we further incorporate time-fixed effects. The firm size effect remains robust, while the policy dummy becomes insignificant, as its impact is absorbed by the time-fixed effects.

The results suggest that insurance companies prefer larger listed real estate companies, likely due to their higher liquidity—consistent with prior literature. This finding remains unchanged following the implementation of Solvency II in 2016. However, we observe a decline in real estate investment in that year, possibly reflecting a policy-induced shock. In contrast, the relationship with revenues is statistically significant but negative. Although initially counterintuitive, this may reflect insurers' aversion to operational risk: real estate firms with higher revenues often achieve them through riskier or more cyclical activities, such as large-scale development or overseas expansion. Given their relatively risk-averse nature, insurance companies may favour firms with more stable income streams to ensure that liabilities can be met sustainably.

Table 12. Insurers' investment decision for listed real estate

	Model (1)	Model (2)	Model (3)	Model (4)
Constant term	-11.56*** (1.79)	-10.19*** (1.55)	-10.98*** (1.84)	-9.74*** (1.59)
Size	0.88*** (0.10)	0.83*** (0.09)	0.82*** (0.10)	0.79*** (0.085)
Revenue	-0.24*** (0.09)	-0.27*** (0.08)	-0.17** (0.09)	-0.23*** (0.08)
Debt	0.037 (0.09)	-0.12 (0.08)	0.06 (0.09)	-0.12 (0.08)
2016	-3.35* (1.73)	-2.64* (1.5)	-1.34 1.799	-1.01 (1.56)
2016*Size	0.13 (0.08)	0.09 (0.07)	0.09 (0.08)	0.05 0.07
Country fixed effects		Yes		Yes
Time fixed effects			Yes	Yes
Adjusted R-squared	24.13%	44.80%	29.52%	48.50%
Numbers of observations	1,118	1,118	1,118	1,118

Notes: This table reports the relationship between investments value of insurers and listed real estate firm characteristics based on estimating equation (8), using annual data over 1997 to 2024. Numbers in parentheses denote the corresponding standard errors for the coefficients. ***, ** and * denote significance levels at 1%, 5% and 10%, respectively.

11. Future Research Avenues

This study acknowledges several limitations that suggest promising directions for future research. First, the analysis treats listed real estate as a relatively homogeneous asset class. However, business-model variation is becoming increasingly important, particularly as European listed real estate shifts from predominantly passive, long-income and triple-net structures towards more operationally intensive owner-operator models. Investigating whether hedge effectiveness and optimal allocations differ by operational intensity would enhance understanding of how managerial capabilities and operating leverage influence the role of listed real estate in liability-driven strategies, providing implications for both active and passive investors.

Second, while the framework focuses on liability-matching dynamics from an inflation-hedging perspective, climate-transition and physical-risk considerations are also highly relevant. For institutions with long-dated liabilities, these risks are increasingly central to long-term balance-sheet resilience and regulatory oversight. A comparative assessment of how different routes to real estate exposure (listed, unlisted and direct) help manage climate-related and physical risks, including energy-efficiency improvements, retrofit execution and associated capital costs, would provide valuable practical insights and enhance the policy relevance of this research.

12. Conclusions

This study contributes to the literature by investigating the role of real estate in mixed-asset portfolios of European insurance companies. While prior research has focused largely on pension funds, this report recognises insurers as the dominant institutional investors in Europe and explicitly accounts for their unique regulatory and liability-driven investment constraints. By combining asset-only portfolio analysis with asset-liability modelling, the study offers a realistic and policy-relevant evaluation of listed real estate from an insurer's perspective.

We consider three routes to real estate investment: direct real estate, listed real estate, and unlisted real estate. Classic mean-variance portfolio optimisation indicates that listed real estate delivers diversification benefits with limited contribution to portfolio performance by enhancing risk-adjusted returns, while unlisted real estate, replacing direct real estate, acts as effective risk diversifiers along the efficient frontier. Yet such an approach is incomplete, as insurers must manage liabilities alongside assets.

To address this, we employ two ALM frameworks under regulatory constraints of Solvency II: one focuses on minimising the risk of the tracking error of surplus, and the other incorporates the liability hedge credits. Both approaches yield consistent results. First, direct real estate plays little or no role, as its function is subsumed by the unlisted real estate. Second, in contrast to mean-variance or asset-only optimisation, the contribution of listed real estate becomes more pronounced in ALM, with optimal allocations ranging from 6.51% to 16.29%, depending on the risk appetite, modelling approach, and liability proxy. These findings are robust across three liability proxies: technical provisions, total liability and duration-matched portfolio. Across a range of model specifications, optimal allocations remain economically significant and consistent with Solvency II capital requirements, underscoring the asset class's relevance for insurers' long-term strategic allocation decisions.

Listed real estate's importance derives not from superior risk-adjusted returns but from its liability-hedging properties. It exhibits strongest correlations with liability proxies across three real estate assets and achieves strongest hedging scores among all of the assets. It is known that listed real estate serves as an effective inflation hedge, particularly against expected inflation. This can explain listed real estate's strong liability hedging ability. Comparisons with actual allocations by the insurers further support our results. Historically, insurers have shown declining interest in direct real estate but increased allocations to listed and unlisted real estate. Our suggested outcomes align closely with these real patterns.

We also examine whether the high capital requirement of listed real estate constrains its role in portfolios. The effective change of relaxing the requirement and treating listed real estate as a long-term investment increases its allocation and enhances performance of the portfolio of the highest risk-adjusted surplus. The results remain largely consistent across subperiods, though estimates display greater variability during periods of market disruption, such as COVID-19 pandemic and the Russia-Ukraine war. Finally, panel regression evidence from eleven European countries suggests that firm size is the key driver of insurers' allocations to listed real estate. This highlights the importance of liquidity considerations in shaping portfolio decisions.

Overall, these findings reinforce the strategic role of listed real estate within institutional portfolios. The evidence indicates that, although listed real estate may not outperform solely on risk-return grounds, it provides distinctive liability-hedging benefits alongside superior liquidity and active asset-management features—attributes that are particularly valuable in environments characterised by inflation uncertainty and liability sensitivity. Listed real estate complements and strengthens portfolio construction by enabling flexible rebalancing, providing real-time market

information, and offering a dynamic inflation-hedging mechanism. As a listed asset class, it also forms part of insurers' equity allocation, making its treatment under LTE especially relevant for long-term strategic portfolio construction. Accordingly, listed real estate should be regarded not merely as a liquid proxy for direct real estate, but as a critical component of liability-driven investment strategies, particularly important in long-term inflation-protection frameworks. The results of this research have important implications for portfolio design, suggesting that listed real estate warrants a strategic allocation for insurers and other liability-driven institutional investors.

From a practical perspective, the results suggest that European insurers may be under-allocated to listed real estate relative to its potential contribution to portfolio efficiency and surplus stability. For asset managers and advisors, the findings highlight the importance of considering listed real estate as a strategic allocation rather than a tactical or residual exposure.

In conclusion, this report demonstrates that listed real estate can play a meaningful role in enhancing the performance and resilience of European insurers' portfolios. By improving diversification, supporting risk-adjusted surplus outcomes, and offering a flexible form of real estate exposure, listed real estate aligns well with insurers' liability-driven objectives. These insights contribute to a more nuanced understanding of real estate's role in institutional portfolios and provide a robust foundation for future research and policy discussion.

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