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Real Estate Exposure and Investment Performance of Pension Funds: Evidence from OECD Countries

COMMISSIONED BY THE IPF RESEARCH PROGRAMME

This research was funded and commissioned through an extension to the IPF Research Programme 2022-2025.

This Programme supports the IPF's wider goals of enhancing the understanding and efficiency of property as an investment. The initiative provides the UK property investment market with the ability to deliver substantial, objective and high-quality analysis on a structured basis. It encourages the whole industry to engage with other financial markets, the wider business community and government on a range of complementary issues.

The Programme is funded by a cross-section of businesses, representing key market participants. The IPF gratefully acknowledges the support of these contributing organisations:

INTRODUCTION

In 2025, the IPF Research Programme launched its fourth grants scheme to provide financial assistance to promote real estate investment research. Prospective applicants were encouraged to examine issues that would advance the real estate investment industry's understanding of and implications for asset pricing, risk adjusted performance and investment strategy. The scheme was also open to individuals, working within institutional organisations, where the grant may be used to fund data acquisition.

The Grant scheme was first run in 2021, and again in 2023 and 2024. This time, an appraisal of proposals received by the deadline of 18 September 2025 resulted in the provision of grants to two submissions, with limited supervision afforded by a sub-committee of the IPF Research Steering Group during the research period.

Each paper, when finalised, is available to download from the IPF website. We hope you find them a diverse and interesting read.

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Richard Gwilliam
Chair IPF Research Steering Group
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Executive Summary

This study investigates the effect of pension funds' real estate holdings on their investment performance, using data from 12 OECD countries between 2007 and 2023. The main objective is to assess whether greater exposure to real estate improves the investment performance of pension portfolios and whether this effect remains consistent under different market conditions.

The empirical findings reveal three main conclusions. First, higher real estate allocations are consistently associated with stronger pension fund performance. This relationship holds across countries, macroeconomic environments, and crisis periods, and remains significant even after controlling for real estate benchmark returns—indicating that the performance effect is not merely driven by general movements in property markets.

Second, the positive association between real estate exposure and pension fund performance remains present during periods of severe market stress. During both the Global Financial Crisis and the COVID-19 period, the relationship between real estate allocations and performance does not materially differ from that observed in non-crisis periods, indicating that market stress neither amplifies nor weakens the estimated effect.

Third, institutional and macro-financial characteristics play a substantial role in shaping outcomes. Countries with more developed pension sectors tend to achieve higher returns, while interest-rate dynamics and inflation conditions meaningfully influence performance. Higher interest rates correspond to stronger nominal returns, whereas inflation erodes nominal returns, underscoring the importance of maintaining price stability.

Overall, the evidence demonstrates that real estate holdings play a meaningful role in enhancing pension fund investment performance, supporting their inclusion in long-term portfolios.

The research leads to the following policy implications:

- **Encourage strategic real estate allocations:** Regulators could design flexible frameworks that allow pension funds to include real estate as a long-term asset class within well-defined governance and risk parameters.
- **Acknowledge real estate's stabilising role in crises:** Policymakers may recognise that the positive association between real estate exposure and pension fund performance remains present during crisis periods, suggesting that the role of real estate within pension portfolios does not materially change during market-wide downturns.
- **Enhance transparency and market infrastructure:** Improved valuation standards, reporting practices, and secondary-market liquidity would enable more efficient and reliable real estate investments by pension funds.
- **Fund size and real estate exposure:** The results indicate that larger pension funds exhibit higher investment performance, while real estate allocations remain positively associated with performance after controlling for fund size. This suggests that scale-enhancing arrangements may be relevant in long-term pension investment strategies.

1. Introduction

Over the past two decades, global pension funds have faced an increasingly complex investment landscape, shaped by prolonged periods of low interest rates, rising inflationary pressures, and recurrent financial crises. In this challenging environment, institutional investors have sought to enhance portfolio resilience and achieve stable long-term returns by expanding their allocations to real assets, particularly real estate. Property investments—both direct and indirect—are widely regarded as attractive for pension funds because they offer diversification benefits, stable income streams, and potential inflation-hedging capabilities (Hudson-Wilson et al., 2005; Hoesli & Lekander, 2008). These characteristics make real estate a natural complement to traditional holdings in equities and fixed income. However, despite these theoretical advantages, empirical evidence of the effectiveness of real estate exposure in improving pension fund performance remains mixed and context dependent.

Previous research provides inconclusive results regarding the contribution of real estate to institutional portfolios. Some studies report that real estate enhances risk-adjusted returns and strengthens long-term stability, particularly when managed actively by large funds with in-house expertise and scale advantages (Andonov, Eichholtz, & Kok, 2013; Dyck & Pomorski, 2011). Others emphasise persistent challenges such as illiquidity, valuation smoothing, and limited transparency, which may distort performance assessment and hinder timely portfolio adjustments during market downturns (Fuerst & Marcato, 2009; Cheng, Lin, & Liu, 2010). Moreover, the extent to which real estate supports portfolio resilience appears to depend on macro-financial conditions, regulatory structures, and market maturity, suggesting that the performance implications of property investments are not uniform across countries or over time.

Although the diversification role of real estate is well established in theory, cross-country empirical evidence within the pension fund context remains scarce. Most existing studies focus on single markets—such as the United States or the Netherlands—where both pension and real estate sectors are highly developed (Hoesli & Oikarinen, 2012). Consequently, little is known about how real estate allocations shape investment performance across heterogeneous pension systems, particularly during episodes of financial stress. This knowledge gap is critical, as the increasing share of illiquid assets in pension portfolios raises new questions about their contribution to financial stability and long-term value preservation under diverse macroeconomic environments.

This study addresses these gaps by examining the relationship between real estate allocations and pension fund investment performance across 12 OECD countries over the period 2007–2023. Drawing on a comprehensive dataset compiled from the OECD, BIS, IMF, and World Bank, the analysis investigates whether higher real estate exposure enhances investment performance and whether these effects differ between crisis and non-crisis periods. The study also incorporates interaction terms for the Global Financial Crisis (2008–2009) and the COVID-19 Crisis (2020-2021) to evaluate whether real estate provides a stabilising effect during periods of systemic stress.

Using a multi-country panel and complementary econometric approaches, the analysis documents a robust association between pension fund real estate exposure and investment performance across countries and over time, which remains stable across alternative specifications and macro-financial conditions. This evidence provides new cross-country insights into the role of real estate within pension fund portfolios without presuming specific diversification or causal mechanisms.

The relationship remains robust across multiple robustness tests, including the exclusion of crisis years, winsorization of extreme observations (1% and 5%) - where the top and bottom 1% and 5% of the data are trimmed to reduce the influence of outliers - and dynamic panel estimations to address potential endogeneity bias.

This study contributes to the literature in three main ways. First, it provides a systematic cross-country analysis of the relationship between pension fund real estate allocations and investment performance using harmonised data from 12 OECD countries over the period 2007–2023. Second, it evaluates the stability of this relationship across different macro-financial conditions by explicitly accounting for crisis periods and alternative econometric specifications. Third, it incorporates institutional characteristics, such as fund size, to shed light on how structural features of pension systems interact with long-term investment outcomes.

The remainder of the paper is structured as follows. Section 2 reviews the relevant literature on real estate and pension fund investment behaviour. Section 3 presents the data. Section 4 illustrates the empirical methodology. Section 5 reports the empirical results and Section 6 shows robustness checks. Section 7 discusses the policy implications and concludes.

2. Literature Review

2.1. The Role of Real Estate in Institutional Portfolios

Real estate has long been recognised as a vital component of institutional investment portfolios due to its low correlation with traditional assets such as equities and bonds and its potential to enhance diversification and risk-adjusted returns (Hudson-Wilson, Fabozzi, & Gordon, 2005; Hoesli & Lekander, 2008). The diversification benefits of real estate stem from its distinctive risk–return characteristics, particularly its inflation-hedging ability and income stability derived from long-term leases (Hoesli, Lekander, & Witkiewicz, 2004).

However, several studies also highlight the limitations of real estate investments, particularly their illiquidity, valuation lags, and appraisal smoothing effects, which can mask underlying volatility (Fuerst & Marcato, 2009; Ling & Naranjo, 2015). Consequently, real estate may act as both a stabiliser and a potential drag on performance, depending on the measurement period and market conditions.

The theoretical foundation for including real estate in multi-asset portfolios often draws from mean-variance optimisation and life-cycle investment theory, where investors seek assets that

offer long-term stability and protection against macroeconomic shocks (Markowitz, 1952; Campbell & Viceira, 2002). For pension funds—long-horizon institutional investors—real estate's duration matching and income-generating attributes make it especially attractive as a liability-hedging asset (Cannon & Cole, 2011).

2.2. Pension Funds' Asset Allocation Behaviour

Pension funds are among the largest global investors, collectively holding over USD 60 trillion in assets (OECD, 2023). Their asset allocation decisions are influenced by multiple factors, including regulation, funding status, risk tolerance, and market development (Ambachtsheer, 2016; Davis & Hu, 2008). Historically, OECD pension funds have demonstrated home bias and a strong preference for fixed-income instruments, especially in countries with conservative investment regulation or immature capital markets (Impavido, Musalem, & Tressel, 2003).

Empirical research indicates that pension funds with more diversified portfolios—including significant real estate and equity exposures—tend to achieve superior long-term performance and greater resilience to market volatility (Andonov, Eichholtz, & Kok, 2013; Dyck & Pomorski, 2011). Yet, despite these potential benefits, real estate allocations remain relatively small in most OECD countries, averaging 8–12% of total assets, often dominated by indirect vehicles such as real estate investment trusts (REITs) or private equity-style funds (Preqin, 2023).

The low equity and real estate exposure observed in countries like Turkey or Portugal reflects structural and regulatory constraints rather than strategic inefficiency (OECD, 2023). For example, quantitative investment limits, valuation rules, and limited secondary markets for property assets tend to reinforce a conservative bias toward bonds and money market instruments (Pillar & Roldán, 2019).

2.3. Real Estate and Pension Fund Performance

Several empirical studies examine how real estate affects pension fund outcomes, yet findings remain mixed.

- Andonov et al. (2013) provide cross-country evidence that active management of real estate portfolios contributes positively to net returns, particularly for larger funds with in-house expertise.
- Thomas, Spataro, & Mathew (2014) show that pension funds' asset allocation patterns can influence stock market volatility, suggesting stabilising effects during downturns.
- Xue, He, & Hu (2021) further demonstrate that pension funds, compared to mutual funds, exert a stabilising influence on national markets, owing to their long-term, countercyclical investment behaviour.

Nevertheless, other studies caution that real estate's valuation smoothing can artificially reduce perceived volatility, overstating diversification benefits (Fuerst & Marcato, 2009). Moreover, Cheng, Lin, & Liu (2010) note that illiquidity in thinly traded real estate markets can amplify

portfolio risk during financial stress, as funds face difficulties rebalancing or meeting redemption demands.

The performance impact also depends on investment channel. Direct property holdings, while offering greater control and transparency, require management expertise and can involve high transaction costs. Indirect vehicles, such as listed REITs, improve liquidity but increase exposure to broader equity-market volatility (Hoesli & Oikarinen, 2012). The choice between these channels often reflects institutional constraints, size, and regulatory context.

2.4. The Impact of Crises and Macroeconomic Conditions

The 2008 Global Financial Crisis (GFC) and the 2010–2011 European Debt Crisis underscored the sensitivity of pension fund performance to macro-financial instability. During crisis periods, real estate's role as a defensive asset was mixed—while it initially helped buffer losses, liquidity shortages and declining property values eventually eroded returns (Pagliari, Scherer, & Monopoli, 2005).

Post-crisis research (e.g., Gonzalez, van Lelyveld, & Lučivjanská, 2020) emphasises fund size and governance quality as key determinants of resilience. Larger funds are better equipped to diversify internationally, manage illiquidity, and capitalise on market dislocations. Similarly, financial development, proxied by credit availability and capital market depth, mediates the relationship between real estate exposure and performance—countries with mature financial systems tend to integrate real estate more effectively into diversified portfolios (Thomas et al., 2014; OECD, 2023).

2.5. Gaps in the Literature and Contribution of the Present Study

Despite growing interest in alternative assets, cross-country evidence on pension funds' real estate exposure remains scarce. Existing studies often focus on single-country analysis (e.g., U.S., U.K., Netherlands) or specific asset classes, limiting their generalisability (Andonov et al., 2013; Hoesli & Lekander, 2008). Moreover, only few papers explicitly model the interaction between real estate exposure and macroeconomic or crisis conditions—a crucial gap given the cyclical nature of property markets.

This proposed study addresses these gaps by:

- Constructing a 12-country panel (2007–2023) using standardised OECD, BIS, IMF, and World Bank data, enabling systematic cross-country comparison.
- Distinguishing between crisis and non-crisis periods, thereby quantifying the resilience benefits (or costs) of real estate holdings.
- Integrating institutional and macroeconomic variables—such as fund size, financial development, and inflation—to capture the broader environment shaping asset allocation outcomes.

- Emphasising policy relevance, by linking findings to regulatory design and the balance between long-term stability and return objectives in pension investment frameworks.

2.6. Conceptual Framework

Building on Modern Portfolio Theory, institutional investment theory, and resilience-based frameworks, the study conceptualises real estate as both a risk-diversifying and shock-absorbing asset within pension portfolios. The hypothesis is twofold:

H1: Higher real estate exposure is associated with improved pension fund performance.

H2: The association between real estate exposure and pension fund performance remains significant during crisis periods.

By empirically testing these hypotheses, the research contributes to both academic theory and policy debate on how pension funds can use illiquid real assets to enhance their investment performance.

3. Data Description

We construct a yearly panel dataset for 12 OECD countries (Australia, Austria, Costa Rica, Czechia, Finland, Germany, Ireland, Israel, Latvia, Portugal, United Kingdom, United States) over the period from 2007 to 2023. The number of countries and time period mainly depends on the availability of the pension funds' (PF) real estate holdings and investment returns. Table 1 lists the variables employed in this study, along with their definition and sources. The selection of variables is guided by the approaches used in Andonov et al. (2012), Thomas et al. (2014), and Gonzalez et al. (2020).

Table 1. Variable Definition and Sources

Variable	Definition	Source
IP	Investment performance of pension funds (%), defined as the annual nominal return.	OECD Global Pension Statistics Database
PFRI	The share of PFs' real estate investments in the total portfolio (%), defined as the share of pension funds' total investment portfolios allocated to real estate at the country level. [1]	OECD Global Pension Statistics Database

[1] This variable is calculated as the ratio of aggregate direct property holdings to total pension fund assets in each country-year. Because the data are available only at the system level, the measure reflects the average allocation to direct property across all pension funds within a country, rather than fund-level exposures. The denominator ("total portfolio") refers to the total investment assets of the pension fund system.

CRISISGFC	A dummy variable equal to 1 for the crisis period (2008-2009) and 0 otherwise	The author
CRISISCOV	A dummy variable equal to 1 for the crisis period (2020-2021) and 0 otherwise	The author
*PFRI*CRISISGFC*	The interaction term between pension funds' real estate investments *(PF)* and a crisis dummy variable (*CRISISGFC)*	The author
*PFRI*CRISISCOV*	The interaction term between pension funds' real estate investments *(PF)* and a crisis dummy variable *(CRISISCOV)*	The author
REB	An index compiled by the Bank for International Settlements (BIS) that measures the residential property prices across countries	BIS
PFS	The total pension funds' assets as a percentage of GDP (%)	OECD Global Pension Statistics Database
SMCAP	Stock market capitalization as a percentage of GDP (%)	World Bank
INT	The interest rate on the 10-year government debt index	OECD
GDP	The growth rate of GDP	IMF International Financial Statistics
CPI	The percentage change of the consumer price index	IMF International Financial Statistics

Figure 1 illustrates the nominal annual investment performance of pension funds across 12 OECD countries over the period 2007–2023. The data reveal a cyclical but generally positive trend, with notable fluctuations corresponding to major global financial events.

Performance remained robust before the 2008 Global Financial Crisis, after which returns declined sharply, reaching approximately –10% in 2008—the lowest point in the series. The subsequent recovery was swift, with double-digit gains in 2009–2010, reflecting asset price rebounds and monetary stimulus across OECD markets. From 2011 to 2017, returns stabilised within a moderate 4–8% range, consistent with a low-interest-rate environment and improving equity valuations.

The COVID-19 pandemic shock in 2020 introduced renewed volatility. Although 2020 saw a brief dip, strong fiscal and monetary responses supported a rebound by 2021, when returns again approached 10%. However, 2022 marked another downturn (around –10%), coinciding with global inflation surges, rising interest rates, and sharp declines in both equity and bond markets. The following year (2023) showed a solid recovery, with average returns returning to the positive territory near 8%.

Overall, the data demonstrate that while pension fund performance is sensitive to global financial cycles, the long-term nominal trend remains positive. Crisis periods—particularly the Global Financial Crisis and COVID-19 periods—exert pronounced negative effects, but recovery phases have historically restored average returns, highlighting the resilience of diversified, long-term pension investment strategies in OECD countries.

Figure 1. Investment Performance of Pension Funds (%) (2007-2023)

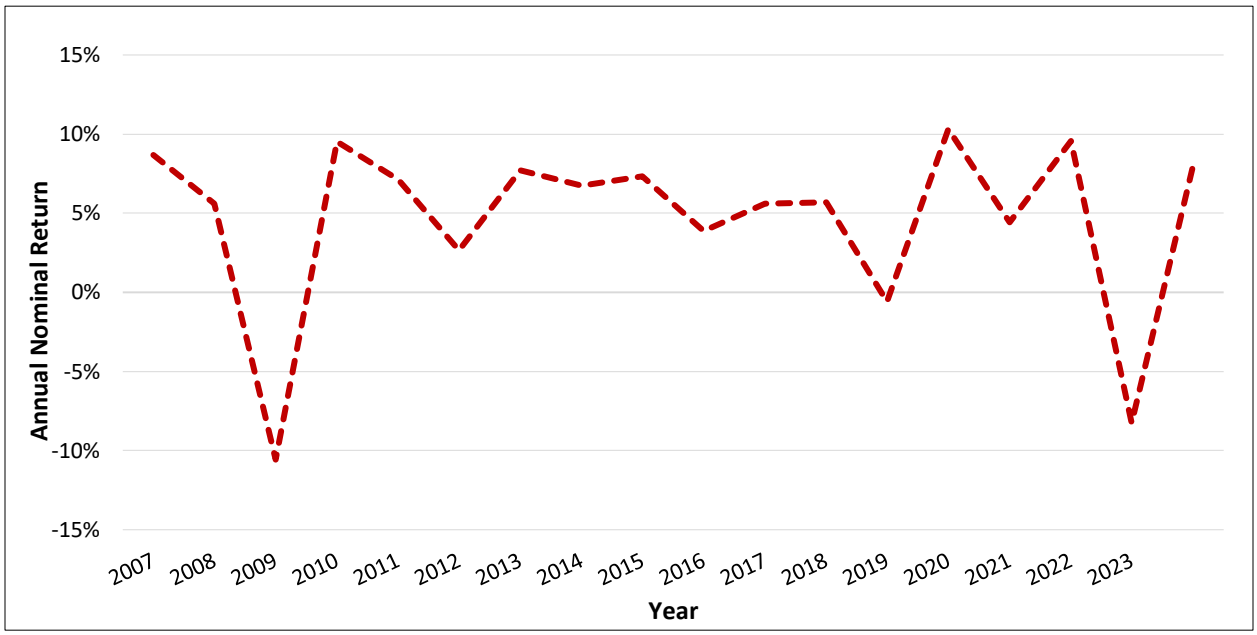

Table 2 presents the descriptive statistics for the main variables used in the panel data analysis, covering 12 OECD countries between 2007 and 2023. The table reports descriptive statistics based on variable-specific data availability. Since pension fund real estate investment (PFRI) is the key explanatory variable, all regression specifications are estimated on the subsample of country–year observations for which PFRI is observed.

The dependent variable, Investment Performance (IP), has an average of 4.3% with a standard deviation of 7.3%, ranging from –35.0% to 24.8%, suggesting moderate variation across countries and years. The negative minimum indicates that some countries experienced outright losses in investment performance during certain years, likely reflecting the impact of global or regional crises.

The key independent variable, Pension Fund Real Estate Investment (PFRI), averages 2.2%, indicating that real estate investments represent a relatively small share of pension fund portfolios on average. Consistent with the bounded nature of portfolio weights, allocations range from zero to a maximum of 11.1%, with most observations clustered at low values.

Real Estate Benchmark Return (REB) has an average of 4.4% and a standard deviation of 7.2%, which suggests that real estate markets show a similar level of volatility to pension fund returns, consistent with the cyclical nature of property markets. The Pension Fund Size (PFS) variable has a mean of 33.9% and a wide range (0.4%–147.5%), implying significant heterogeneity in the relative scale of pension assets across countries. Stock Market Capitalization to GDP (SMCAP) averages 57.2%, indicating that, on average, equity market depth is around 57% of GDP across the sample. This ratio reflects the degree of financial development and capital market sophistication, which may positively correlate with pension fund investment efficiency.

The interest rate (INT) and GDP growth (GDP) variables display means of 2.6% and 4.5%, respectively. The moderate standard deviations indicate stable macroeconomic conditions over most of the sample, though negative values in some years capture recessionary periods. Finally, inflation (CPI) has a mean of 2.6%, suggesting an average annual inflation rate of around 2.6%, consistent with OECD averages. The variability (SD = 3.0%) shows that inflation remained relatively contained, with few extreme values (min = –4.4%, max = 17.3%).

Overall, these statistics reveal that the dataset captures diverse macroeconomic environments and pension fund structures. The moderate variation in key financial indicators suggests sufficient cross-country and time-series heterogeneity to explore the relationship between pension fund real estate exposure and investment performance, both in normal and crisis periods.

Table 2. Summary Statistics

Variable	Obs	Mean	Std. dev.	Min	Max
IP	180	0.043	0.073	-0.350	0.248
PFRI	145	0.022	0.028	0.000	0.111
CRISISGFC	204	0.118	0.323	0.000	1.000
CRISISCOV	204	0.118	0.323	0.000	1.000
PFRI X *CRISISGFC*	145	0.003	0.014	0.000	0.093
PFRI X *CRISISCOV*	145	0.003	0.014	0.000	0.106
REB	202	0.044	0.072	-0.293	0.258
PFS	204	0.339	0.35	0.004	1.475
SMCAP	113	0.572	0.446	0.000	1.949
INT	170	0.026	0.02	-0.005	0.105
GDP	204	0.045	0.092	-0.249	0.441
CPI	204	0.026	0.03	-0.044	0.173

4. Empirical Methodology

We analyse the effect of PFs' real estate investments on investment performance using the following panel regression model:

$$IP_{i,t} = a_i + \beta_1 PFRI_{i,t} + \beta_2 CRISISGFC_t + \beta_3 CRISISCOV_t + \beta_4 PFRI_{i,t} * CRISISGFC_t + \beta_5 PFRI_{i,t} * CRISISCOV_t + \beta_6 X'_{i,t} + u_{i,t},$$

where $IP_{i,t}$ is the investment performance of pension funds for country *i* at time *t*, $PFRI_{i,t}$ is PFs' real estate investments, $X'_{i,t}$is a matrix of control variables (pension fund size, stock market capitalization, real estate benchmark return, interest rate, GDP, and CPI), a_i, is the country *i* fixed effect, and $u_{i,t}$ is the error term.

In this panel regression framework, we use two crisis dummies: $CRISISGFC_t \; and \; CRISISCOV_t$,where each dummy equals to 1 during the 2008-2009 and 2020-2021 crisis years, respectively, and 0 for the other years. The crisis dummies model the difference in investment performance of pension funds between the crisis years and the average of the non-

crisis years. We also interact the crisis dummies with the PFs' real estate investments variable ($PFRI_{i,t} * CRISISGFC_t$ and $PFRI_{i,t} * CRISISCOV_t$) to analyse whether PFs' impact on investment performance is different during crisis periods.

5. Results

5.1. Panel Regression Tests

Before interpreting the model coefficients, several panel regression diagnostic tests were conducted to verify the statistical appropriateness of the chosen specification and estimators (see Table 3). The Hausman test (p = 0.016) was applied to compare the fixed-effects and random-effects estimators. The statistically significant p-value (below 0.05) indicates that the fixed-effects model is preferred, confirming that unobserved country-specific characteristics are correlated with the explanatory variables. This finding suggests that these country-specific effects systematically influence pension fund investment performance, justifying the use of the fixed-effects framework.

The Modified Bhargava Durbin–Watson statistic (2.084) and the Baltagi–Wu LBI statistic (2.341) were used to test for serial correlation in the panel residuals. Since both values are close to 2, the results suggest no severe autocorrelation problem, supporting the reliability of the fixed-effects estimates. However, the Wooldridge test (p = 0.009) revealed the presence of first-order autocorrelation, meaning that residuals are correlated over time within countries. To address this issue, the estimations were corrected using Driscoll–Kraay and Panel-Corrected Standard Errors (PCSE), which provide robustness against autocorrelation and other forms of serial dependence.

The Modified Wald test (p = 0.000) confirmed the existence of groupwise heteroskedasticity, indicating that error variances differ across countries. This finding further supports the use of robust and PCSE estimators, which correct for heteroskedasticity across panels. Similarly, the Likelihood-Ratio (LR) test (p = 0.000) showed that time fixed effects are jointly significant, implying that common shocks or global time-specific factors—such as financial crises—affect all countries simultaneously. Therefore, a two-way fixed-effects specification, accounting for both country and year effects, was adopted. Finally, the Pesaran Cross-Sectional Dependence (CD) test (p = 0.000) revealed significant cross-sectional dependence, suggesting that shocks in one country's pension market can spill over to others, particularly during global financial events. To ensure consistency of the standard errors in the presence of such dependence, the Driscoll–Kraay and PCSE corrections were again applied.

Taken together, these diagnostic results confirm that the data exhibit autocorrelation, heteroskedasticity, and cross-sectional dependence. As a result, a two-way fixed-effects panel model with robust, Driscoll–Kraay, and PCSE standard error corrections was employed to obtain efficient and unbiased estimates that account for these econometric challenges.

5.2. Panel Regression Results

Table 3 reports the results of three fixed-effects panel regressions examining the determinants of pension fund investment performance (IP) across 12 OECD countries between 2007 and 2023. The dependent variable is the annual investment performance of pension funds, while the key explanatory variable is the share of pension fund assets invested in real estate (PFRI). Columns (1), (2), and (3) present results using fixed-effects estimation with robust, Driscoll–Kraay, and panel-corrected standard errors, respectively, to account for potential heteroskedasticity, serial correlation, and cross-sectional dependence.

Across all model specifications, the coefficient of PFRI is positive and statistically significant at the 5% level in Models (1) and (2), and significant at the 10% level in Model (3), indicating that a higher allocation to real estate investments is associated with better pension fund performance. This result supports the hypothesis that real estate contributes positively to long-term portfolio diversification and return stability, consistent with the literature emphasising its inflation-hedging and low-correlation properties relative to equities and bonds.

The Global Financial Crisis (CRISISGFC) dummy exhibits a negative and statistically significant coefficient across all model specifications, indicating that pension fund investment performance was, on average, lower during the 2008–2009 crisis period even after accounting for year fixed effects. Since the model includes time fixed effects, the CRISISGFC coefficient captures the additional common deviation in performance across the two crisis years beyond year-specific global shocks. In contrast, the COVID-19 crisis dummy (CRISISCOV) is negative but statistically insignificant, suggesting that once year-specific effects are controlled for, the pandemic period did not generate a uniform additional impact on pension fund returns across countries.

Interestingly, the interaction term between PFRI and the Global Financial Crisis (PFRI × CRISISGFC) is positive and significant in the first model, suggesting that funds with higher real estate exposure performed relatively better during the GFC. This finding indicates that real estate investments may have provided partial downside protection or delayed valuation effects compared to more liquid asset classes. However, the interaction with the COVID Crisis (PFRI × CRISISCOV) is negative but not significant.

Among control variables, the real estate benchmark return (REB) has a strong and positive effect (0.380, significant at 1%), confirming that broader real estate market performance is an important determinant of pension fund returns. This means that the superior performance cannot be explained solely by broader movements in property markets. Pension funds appear to generate genuine excess returns through active management, allocation discipline, and strategic timing in real estate investment. Similarly, pension fund size (PFS) is positive and highly significant, suggesting that larger funds tend to achieve better investment performance, likely due to economies of scale, better access to asset management expertise, and enhanced diversification.

The stock market capitalisation-to-GDP ratio (SMCAP) is statistically significant in the third specification, indicating that capital market development is correlated with pension fund performance once cross-sectional dependence is accounted for. The interest rate (INT) variable has one of the largest and most consistent effects across all models, with a coefficient of approximately 2.156, indicating that higher interest rate environments are associated with stronger pension fund performance. By contrast, GDP growth (GDP) shows a positive but mostly insignificant relationship, suggesting that macroeconomic growth alone does not directly translate into short-term investment performance improvements. Inflation (CPI) exhibits a negative and statistically significant coefficient in the robust specification. Since investment performance is measured in nominal terms, this result indicates that higher inflation is associated with weaker nominal pension fund returns. This finding is consistent with the view that inflationary environments pose challenges for portfolio performance even before accounting for inflation adjustments.

Overall, the findings provide robust evidence that real estate investments enhance pension fund performance and this effect is also pronounced during crisis times. The results also emphasise the importance of fund size, interest rate conditions, and market development in shaping pension fund returns. Inflation, by contrast, remains a persistent threat to returns, underscoring the need for dynamic asset allocation and inflation-hedging strategies in pension fund management.

Table 3. Panel Regression Results

Dep. Var.: (IP)			
Variable	**Fixed-Effects (Robust Errors) (1)**	**Fixed-Effects (Driscoll-Kraay Errors) (2)**	**Fixed-Effects (Panel Corrected Standard Errors) (3)**
PFRI	1.902** (0.045)	1.902** (0.025)	1.902* (0.059)
CRISISGFC	-0.111*** (0.007)	-0.111* (0.081)	-0.111** (0.020)
CRISISCOV	-0.013 (0.627)	-0.013 (0.535)	-0.013 (0.733)
PFRI X *CRISISGFC*	1.684* (0.071)	1.684 (0.209)	1.684 (0.265)
PFRI X *CRISISCOV*	-0.998 (0.450)	-0.998 (0.339)	-0.998 (0.504)
REB	0.380*** (0.006)	0.380** (0.016)	0.380** (0.017)
PFS	0.359*** (0.000)	0.359** (0.014)	0.359*** (0.000)
SMCAP	0.077 (0.240)	0.077 (0.128)	0.077** (0.039)
INT	2.156*** (0.001)	2.156** (0.040)	2.156*** (0.001)
GDP	0.160 (0.453)	0.160* (0.095)	0.160 (0.154)
CPI	-1.340** (0.022)	-1.340 (0.133)	-1.340 (0.131)
Constant	-0.305*** (0.008)	-0.305** (0.030)	-0.570*** (0.000)
R-squared (within)	0.526	0.526	0.6441
Hausman Test (p-value)	0.016		
Modified Bhargava DW-statistic	2.084		
Baltagi-Wu LBI statistic	2.341		
Wooldridge test (p-value)	0.009		
Modified Wald test (p-value)	0.000		

Likelihood-ratio test (p-value)	0.000		
Pesaran CD test (p-value)	0.000		

*Note: The ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*

6. Robustness Checks

This section conducts robustness checks to assess the stability of the baseline results. Given the cross-country setting, data constraints, and exposure to macro-financial shocks, these tests ensure that the estimated relationship between pension fund real estate investments and performance is not driven by specification choices, crisis-period dynamics, endogeneity concerns, or extreme observations. The robustness analysis therefore examines whether the main findings persist under alternative estimation methods, subsample definitions, and data treatments.

While several robustness exercises relate to controlling for unusual macro-financial periods, each addresses a distinct source of potential bias. Crisis-period exclusions assess whether results are driven by extreme episodes, winsorization evaluates sensitivity to outliers, and dynamic panel specifications address potential endogeneity. Presenting these specifications separately allows for clearer interpretation of each robustness dimension.

6.1. Endogeneity Bias

Table 4 reports the results of the Arellano–Bond dynamic panel GMM estimations for pension fund investment performance (IP), using both one-lag (AR(1)) and two-lag (AR(2)) specifications. These models account for the dynamic nature of pension fund returns, potential endogeneity of regressors, and unobserved country-specific heterogeneity.

Because the dynamic panel GMM estimator is designed to address endogeneity and persistence rather than to characterise unconditional distributions, the analysis focuses on standard Arellano–Bond diagnostics. Accordingly, we report the AR(1) and AR(2) serial correlation tests and the Hansen test of overidentifying restrictions, which jointly assess the reliability of the dynamic panel estimates. The AR(1) and AR(2) tests indicate no second-order serial correlation, and the Hansen test fails to reject the null of valid instruments. The number of instruments is limited relative to the number of countries, supporting the reliability of the dynamic GMM estimates.

The lagged dependent variables are negative and highly significant in both models, confirming strong mean reversion in investment performance. In the AR(1) specification, the coefficient for IP (L1) is –0.356 (p = 0.000), while in the AR(2) model the first and second lags are –0.458 and –0.424 (p = 0.000 for both). This suggests that exceptionally high returns in one period tend to be followed by lower subsequent returns, a pattern consistent with correction toward long-term equilibrium and the cyclical nature of financial markets.

Across both models, the coefficient on PFRI (pension fund real estate holdings) is positive and highly significant (1.979 in AR(1); 1.920 in AR(2), both p = 0.000). This indicates that greater allocations to real estate consistently enhance pension fund investment performance. The finding reinforces the view that real estate provides diversification benefits and acts as a stabilising asset class with inflation-hedging characteristics, especially valuable for long-term institutional investors.

The results reveal that macro-financial crises significantly affect pension fund performance. During the Global Financial Crisis (CRISISGFC), investment performance declined sharply (coefficient –0.199, p = 0.000), reflecting the severe global downturn in asset prices and liquidity contraction. The COVID-19 Crisis (CRISISCOV) also shows a negative effect in the AR(2) model (–0.047, p = 0.003), though its magnitude is smaller, suggesting that the later crisis had a more contained impact on pension funds.

The interaction term between real estate exposure and the Global Financial Crisis (PFRI × CRISISGFC) is positive but not statistically significant (2.483, p = 0.094), indicating that funds with higher real estate allocations could have performed relatively better during the crisis. Although not sufficient alone, in conjunction with the other models, this result adds additional support to the hypothesis that real estate acted as a partial buffer against systemic market shocks during the 2008–2009 period. In contrast, the interaction with the COVID-19 crisis dummy (PFRI × CRISISCOV) has a very high p-value (p=0.740), implying that real estate did not play an additional performance enhancing role during that episode, likely due to regional contagion effects within European property markets.

Among the control variables, real estate benchmark returns (REB) are positive and statistically significant at the 5% level in the first lag (AR(1)) and at the 10% level in the second lag (AR(2)), indicating that overall real estate market performance has a moderate but meaningful influence on pension fund investment outcomes. The slightly weaker significance in the second lag suggests that the effect of market-level real estate conditions diminishes over time. Pension fund size (PFS) is positive and statistically significant at the 5% level in the first lag and at the 1% level in the second lag, suggesting that larger funds tend to achieve superior performance, likely benefiting from economies of scale, stronger governance, and access to more diversified investment opportunities.

Stock market capitalisation (SMCAP) has a positive effect in the AR(1) model (0.052, p = 0.013), indicating that more developed and liquid capital markets contribute to higher pension fund returns. However, the effect becomes insignificant in the AR(2) model, which may reflect diminishing marginal benefits once dynamic adjustments are accounted for. The interest rate (INT) variable shows a strong and consistent positive relationship with performance in both models (2.152 and 1.439, p = 0.000). This suggests that higher interest rate environments improve fund returns, likely through higher yields on fixed-income securities and revaluation effects on pension portfolios.

GDP growth (GDP) shows mixed results—positive but insignificant in AR(1), and negative and significant in AR(2) (–0.144, p = 0.025)—indicating that short-term economic expansion may not directly translate into investment performance gains. Meanwhile, inflation (CPI) has a positive and significant or weakly significant coefficient in both models (1.134, p = 0.062; 1.989, p = 0.001), implying that pension funds' real estate and other real-asset exposures likely provided inflation protection during high-price periods.

Overall, the dynamic estimations confirm that pension fund performance is path-dependent, with strong persistence and cyclical adjustment. Real estate investment emerges as a robust and performance-enhancing component of pension portfolios, during both non-crisis and crisis periods. Larger funds and those operating in financially developed markets perform better, while inflation and interest rates play significant roles in shaping outcomes.

The consistency of the results across the AR(1) and AR(2) specifications strengthens confidence in the robustness of these findings, highlighting the performance enhancing role of real estate investments in long-term pension fund management.

Table 4. Robustness Check: Endogeneity Bias

Variable	**Model: Arellano–Bond AR(1)** **(1)**	**Model: Arellano–Bond AR(2)** **(2)**
IP (L1)	-0.356*** (0.000)	-0.458*** (0.000)
IP (L2)	—	-0.424*** (0.000)
PFRI	1.979*** (0.000)	1.920*** (0.000)
CRISISGFC	-0.199*** (0.000)	—[2]
CRISISCOV	-0.030 (0.129)	-0.047*** (0.003)
PFRI X *CRISISGFC*	2.483* (0.094)	—
PFRI X *CRISISCOV*	0.152 (0.740)	0.217 (0.480)
REB	0.093** (0.035)	0.143* (0.071)

[2] The number of observations is lower in the AR(2) specification because the use of additional lags leads to the loss of early time-period observations, as standard in dynamic panel GMM estimation.

PFS	0.801*** (0.000)	0.744*** (0.000)
SMCAP	0.052** (0.013)	0.021 (0.360)
INT	2.152*** (0.000)	1.439*** (0.000)
GDP	0.017 (0.610)	-0.144** (0.025)
CPI	1.134* (0.062)	1.989*** (0.001)
Constant	-0.521** (0.027)	-0.427** (0.017)
AR(1) Test (p-value)	0.032	
AR(2) Test (p-value)	0.153	
Hansen Test (p-value)	0.451	

*Note: The ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*

6.2. Excluding Crisis Periods

Table 5 reports the results of fixed-effects regressions estimated using three alternative error-correction methods—robust standard errors, Driscoll–Kraay standard errors, and panel-corrected standard errors (PCSE)—after excluding crisis periods from the sample. Specifically, the Global Financial Crisis years (2008–2009) and the COVID-19 crisis years (2020–2021) are excluded, corresponding exactly to the periods captured by the CRISISGFC and CRISISCOV dummy variables in the baseline specifications. This robustness test evaluates whether the earlier findings are driven by crisis-period dynamics and ensures that the relationship between pension fund real estate allocations and investment performance holds under normal market conditions.

Across all three estimation techniques, the coefficient on Pension Fund Real Estate Holdings (PFRI) remains positive and statistically significant, although the level of significance weakens slightly when accounting for cross-sectional dependence. In the robust-error specification, the coefficient of 1.379 ($p = 0.012$) implies that a one-percentage-point increase in the share of real estate investments is associated with an improvement of roughly 0.014 percentage points in investment performance, ceteris paribus. The coefficient remains of a similar direction in the Driscoll-Kraay and PCSE models, confirming the robust positive impact of real estate exposure

even when turbulent crisis periods are excluded. This consistency supports the argument that real estate allocations enhance long-term returns rather than simply cushioning performance during downturns.

The real estate benchmark (REB) variable is positive and statistically significant at the 1% level in the first model and at the 5% level in the second and third models, indicating that real estate market performance has a strong and consistent influence on pension fund investment outcomes. This suggests that funds benefit from favourable conditions in the broader real estate market, though the effect weakens slightly across alternative estimations. In contrast, stock-market capitalisation (SMCAP) remains statistically insignificant across all models, implying that overall capital-market development exerts a limited impact on pension fund returns once fund-specific characteristics are taken into account. These findings underscore that portfolio composition and fund management strategies play a more decisive role than aggregate market conditions in explaining performance differences across countries.

Pension fund size (PFS) remains strongly positive and significant across all specifications ($p < 0.05$ in every model). Larger funds appear to systematically outperform smaller ones, likely reflecting economies of scale, stronger governance, and greater access to alternative asset classes. This result reinforces earlier findings that institutional maturity and scale contribute meaningfully to pension fund efficiency.

The interest rate (INT) variable is also positive and statistically significant, with coefficients around 1.45 across all models, indicating that higher interest-rate environments are associated with stronger nominal investment performance. This relationship may reflect improved yields on fixed-income instruments and valuation effects favouring pension portfolios with higher duration exposure. By contrast, GDP growth (GDP) and inflation (CPI) remain statistically insignificant, consistent with the notion that macroeconomic fluctuations have a limited short-term effect on portfolio-level performance once structural and institutional differences are taken into account. Inflation retains a positive but imprecisely estimated coefficient, suggesting that any inflation-hedging effect through real assets (e.g., property holdings) is modest outside of crisis periods.

Excluding crisis years does not materially change the direction or significance of the main results, implying that the positive link between real estate exposure and investment performance is structural rather than episodic. The findings suggest that real estate continues to act as a performance-enhancing component of pension portfolios under normal macro-financial conditions, while fund size and interest-rate environments remain key complementary determinants.

Table 5. Robustness Check: Excluding Crisis Periods

Variable	Fixed-Effects (Robust Errors) (1)	Fixed-Effects (Driscoll-Kraay Errors) (2)	Fixed-Effects (Panel Corrected Standard Errors) (3)
PFRI	1.379*** (0.012)	1.379* (0.053)	1.379* (0.079)
REB	0.160*** (0.008)	0.160** (0.023)	0.160** (0.041)
PFS	0.249*** (0.000)	0.249*** (0.006)	0.249** (0.032)
SMCAP	0.030 (0.780)	0.030 (0.619)	0.030 (0.699)
INT	1.446** (0.016)	1.446** (0.022)	1.446** (0.033)
GDP	-0.041 (0.825)	-0.041 (0.222)	-0.041 (0.732)
CPI	0.181 (0.842)	0.181 (0.857)	0.181 (0.856)
Constant	-0.167* (0.072)	-0.167** (0.023)	-0.167 (0.019)
R-squared	0.176	0.176	0.247

*Note: The ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*

6.3. Excluding Outlier Observations

To ensure that the main findings are not driven by outliers or extreme observations, Table 5 reports the results of two additional fixed-effects regressions estimated using winsorized samples. In Model (1), the top and bottom 1 percent of all variables are trimmed, while Model (2) applies a more conservative 5 percent trimming. Both regressions include country and time fixed effects, with standard errors clustered at the country level. Across both specifications, the coefficient on Pension Fund Real Estate Holdings (PFRI) remains positive and statistically significant, confirming the stability of the earlier findings. In the 1 percent-trimmed model, the estimated coefficient of 1.526 ($p = 0.023$) suggests that a one-percentage-point increase in the

share of real-estate investments is associated with roughly a 0.015 percentage points rise in pension-fund investment performance. The coefficient remains similar under 5 percent trimming (1.267 p = 0.019), demonstrating that the positive effect of real-estate allocation is not driven by a small number of outliers. This reinforces the interpretation that real estate exposure structurally enhances pension fund performance, consistent with its diversification and inflation-hedging properties.

The Global Financial Crisis (CRISISGFC) dummy remains significant and negative in the 1 percent-trimmed regression (–0.092, p = 0.020), indicating a clear deterioration in returns during 2008–2009 even after outlier adjustment. This effect becomes statistically insignificant once 5 percent of observations are trimmed, suggesting that the crisis-period variance was heavily influenced by extreme performance values. The COVID Crisis (CRISISCOV) variable is insignificant in the 1 percent model but becomes negative and significant under 5 percent trimming (–0.037, p = 0.029).

The interaction terms between real-estate exposure and the crisis indicators (PFRI × CRISISGFC and PFRI × CRISISCOV) are not statistically significant in the winsorized specifications. This result should be interpreted with caution, however, as a substantial share of the trimmed observations corresponds to crisis years, implying considerable overlap between the winsorization procedure and the exclusion of extreme crisis-period outcomes. Consequently, the lack of significance likely reflects the reduced variation in crisis-related returns rather than evidence that real-estate exposure is irrelevant for pension fund resilience during periods of stress. The real estate benchmark return (REB) is strongly positive and statistically significant in both the 1%-trimmed regression (0.407, p = 0.004) and the 5%-trimmed regression (0.407, p = 0.026). This indicates that the relationship between real estate sector performance and pension fund investment outcomes remains robust even after excluding extreme observations. However, the weaker significance level in the 5%-trimmed model suggests that part of this relationship is influenced by a few high-return cases, though the overall linkage between sectoral returns and pension fund performance persists.

The pension fund size (PFS) variable remains positive and highly significant across both models, with coefficients of 0.347 ($p < 0.001$) and 0.511 ($p = 0.035$). Larger funds consistently outperform smaller ones, likely due to economies of scale, more sophisticated portfolio management, and access to alternative assets.

The interest rate variable (INT) continues to show a strong positive association with investment performance (1.99 and 1.82, both $p \leq 0.001$), supporting the view that higher rates improve nominal returns through increased yields on fixed-income holdings. Inflation (CPI) remains significantly negative in both models, reflecting the erosion of real returns in high-inflation environments despite partial hedging via real assets. GDP growth (GDP) and stock-market capitalisation (SMCap) remain statistically insignificant across all specifications, suggesting that macro-level growth and market depth are less relevant for short-term pension-fund performance than portfolio composition and institutional characteristics.

The winsorized regressions confirm that the positive and significant relationship between pension fund real estate allocations and investment performance is robust to the removal of extreme data points. The persistence of the coefficient across 1 percent and 5 percent trimming levels demonstrates that the observed relationship is not an artifact of a few high-performing or underperforming funds.

Overall, the results indicate that real estate investments play a consistent and meaningful role in enhancing pension fund outcomes across normal market conditions. Crisis effects are reduced once extremes are removed, implying that extreme losses or gains during the Global Financial and COVID-19 had a disproportionate influence on the untrimmed sample.

Table 6. Robustness Check: Winsorized Sample Regressions

Variable	**Model (1): Winsorized 1%**	**Model (2): Winsorized 5%**
PFRI	1.526** (0.023)	1.267** (0.019)
CRISISGFC	-0.092** (0.020)	-0.057 (0.716)
CRISISEDC	-0.005 (0.801)	-0.037** (0.029)
PFRI×CRISISGFC	1.122 (0.191)	0.815 (0.964)
PFRI×CRISISEDC	-1.080 (0.384)	1.189 (0.221)
REB	0.407*** (0.004)	0.246** (0.028)
PFS	0.347*** (0.000)	0.511** (0.035)
SMCAP	0.053 (0.449)	0.020 (0.784)
INT	1.993*** (0.001)	1.822*** (0.001)
GDP	0.195 (0.346)	-0.113 (0.497)
CPI	-1.683*** (0.006)	-1.327** (0.013)

Constant	-0.262** (0.013)	-0.287*** (0.001)

*Note: The ***, **, and * indicate statistical significance at the 1%, 5%, and 10% levels, respectively.*

7. Conclusion and Policy Implications

This study provides robust cross-country evidence that real estate plays a positive and durable role in enhancing pension fund investment performance. Using panel data from 12 OECD countries between 2007 and 2023, the analysis demonstrates that funds allocating a higher share of their portfolios to real estate consistently achieve stronger returns, both in normal times and during episodes of market stress. The relationship remains statistically significant across multiple specifications—fixed-effects, Driscoll–Kraay, panel-corrected, and dynamic GMM models—and survives extensive robustness checks including the dynamic panel estimation, exclusion of crisis periods and winsorization of extreme observations.

The empirical findings point to several clear conclusions. First, higher real estate allocations are associated with stronger pension fund investment performance. This effect persists even when accounting for country-specific factors, macroeconomic variables, and crisis periods. Importantly, the findings remain significant even after controlling for real estate benchmark returns, which means the superior performance cannot be explained solely by broader movements in property markets.

Second, the positive association between real estate exposure and pension fund performance is equally pronounced during crisis periods. During both the Global Financial Crisis (2008–2009) and the COVID-19 period, the relationship between real estate allocations and performance remains comparable in magnitude to that observed in non-crisis periods, with no evidence of additional enhancement or deterioration. This indicates that the performance effect associated with real estate exposure is stable across different macro-financial conditions.

Third, institutional characteristics as well as macroeconomic conditions are also associated with pension fund investment performance. Larger pension funds consistently exhibit higher investment performance than smaller ones across specifications. Interest rate conditions are positively associated with nominal investment performance, while inflation is associated with lower nominal returns, indicating that inflationary environments tend to coincide with weaker pension fund performance.

Taken together, these findings suggest that the positive effect of real estate is systematic, economically meaningful, and robust across model assumptions. The evidence indicates that property investments enhance performance, helping pension funds achieve long-term objectives without significantly increasing volatility or exposure to systemic risk.

The results carry several important implications for regulators, policymakers, and institutional investors designing and overseeing long-term pension investment frameworks.

- **Encourage strategic real estate allocations:** Regulators should design flexible investment frameworks that enable pension funds to treat real estate as a strategic long-term asset class, rather than a marginal alternative investment. Allowing higher but well-supervised allocations can help funds capture the diversification, inflation-hedging, and stable income benefits that real assets offer. Regulatory guidance should emphasise governance quality, liquidity management, and valuation transparency to ensure prudent integration of property into multi-asset portfolios.
- **Acknowledge real estate's stabilizing role in crises:** Policymakers should recognise that real estate continues to enhance pension fund performance even during crisis periods, mitigating downside risks and improving portfolio resilience. The empirical findings show that funds with larger real estate allocations experienced smaller performance declines during the Global Financial Crisis. This suggests that property holdings act as a structural stabiliser—offering steady cash flows and low correlation with public markets—even under adverse macroeconomic conditions.
- **Enhance transparency and market infrastructure:** Effective real estate investment depends on robust valuation standards, data consistency, and liquid secondary markets. Regulators and supervisory authorities should promote standardised appraisal methodologies, mandatory disclosure of valuation assumptions, and transparent reporting of unlisted real estate holdings. Deepening secondary-market liquidity through listed vehicles or real estate investment platforms would further enhance price discovery, reduce valuation lags, and improve investor confidence.
- **Fund size and real estate exposure:** The results indicate that larger pension funds exhibit higher investment performance, and that real estate allocations are positively associated with performance after controlling for fund size. Together, these findings suggest that policies supporting scale-enhancing arrangements among pension funds may be relevant when considering the role of real estate within long-term investment strategies.

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