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One shock fits none? Appraisal smoothing, home bias and the Solvency II property risk charge

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Abstract

The Solvency II standard formula charges all real estate held by European insurers with a uniform 25 per cent shock, calibrated on appraisal-based UK returns. Supervisory data show that insurers hold 6 per cent of their investments in real estate and 94 per cent of their direct holdings at home, so national risk matters. Appraisal-based revaluations of European listed property companies imply a 1-in-200 loss of 11 per cent, rising to 23 per cent after de-smoothing. Unlevered listed property portfolios imply 30 to 35 per cent for Europe and between 9 (Switzerland) and 46 per cent (United Kingdom) across countries. These estimates rest almost entirely on the 2008/09 crisis and are imprecise. The uniform shock is defensible on average but too low for most national markets and well above industry proposals. The equity charge does not steer allocation, because insurers' property equity consists mainly of look-through subsidiaries.

JEL classification: G22; G28; R33

1 Introduction

European insurers are among the largest institutional owners of real estate. At the end of 2025, insurers in the European Economic Area (EEA) held some EUR 420 billion in direct property, real estate funds and property companies, equal to about 6 per cent of their investments outside unit-linked business (Table 1). Under the Solvency II standard formula, capital for this exposure is set by a single stress: the loss in basic own funds from an instantaneous 25 per cent decrease in the value of immovable property (Article 174 of Delegated Regulation (EU) 2015/35). The factor applies to offices in Paris, shopping centres in Manchester and residential blocks in Vienna alike.

The 25 per cent originates in the advice of the Committee of European Insurance and Occupational Pensions Supervisors on the calibration of the market risk module (CEIOPS 2010). CEIOPS estimated the 99.5 per cent value-at-risk of rolling twelve-month total returns of the monthly UK index of the Investment Property Databank (IPD) for 1987 to 2008 and found a loss of 25.7 per cent for all property. It considered but rejected correcting the appraisal-based index for smoothing, and it saw no need for a breakdown by property type because the historical values at risk of the sectors did not diverge much (CEIOPS 2010, paras 4.97, 4.104 and 4.111). The industry contested the calibration from the outset. Studies commissioned by property and insurance associations concluded that a pan-European factor "would be no higher than 15%" (Cullen 2011) and might be reduced to 12 per cent for portfolios outside the United Kingdom (MSCI 2017). Academic re-estimations on the same UK data, in contrast, find that de-smoothed returns imply capital requirements generally above 25 per cent (Durán Santomil et al. 2019).

This paper asks whether the uniform 25 per cent shock adequately reflects the property risk of European insurers. We add three elements to the debate. First, we use the public aggregates of the Solvency II quantitative reporting templates to document how insurers actually hold real estate. Their direct holdings are almost entirely domestic: 94 per cent of directly held investment property is located in the reporting country. A European calibration is therefore relevant only to the extent that national property markets move together in a crisis. Second, we measure tail risk for twelve European countries with two

independent sources outside the UK appraisal index: the IAS 40 fair-value revaluations reported by listed property companies, which are appraisal-based, and the market prices of the same companies, unlevered with their market leverage. Third, we test whether the symmetric adjustment of the equity charge, which changes the relative capital cost of property shares and direct property, affects insurers' allocation.

The results support neither side of the calibration debate fully. Raw appraisal data understate tail risk by about half: the 0.5 per cent quantile of country-level revaluation rates is − 11.2 per cent, and it rises to − 22.7 per cent after de-smoothing. Market-based returns of unlevered listed property portfolios give − 30.3 per cent (equal-weighted) and − 32.8 per cent (value-weighted) for Europe, and − 32.8 to − 35.0 per cent when changes in the market value of debt are taken into account. National estimates range from − 9.3 per cent in Switzerland to − 45.9 per cent in the United Kingdom; seven of twelve countries exceed 25 per cent in equal-weighted and ten in value-weighted portfolios. The industry position of 15 per cent is clearly inconsistent with market prices. The precision of all these numbers is low, however. They are determined by a single episode, the 2008/09 financial crisis: excluding windows ending in 2008 to mid-2010 reduces the European equal-weighted quantile to − 10.5 per cent, and the 90 per cent block-bootstrap interval ranges from − 31.3 to − 9.0 per cent. Finally, we find no reallocation in response to the symmetric adjustment, which is consistent with the regulatory treatment: most of what insurers report as property equity are participations in property subsidiaries that are capitalised on a look-through basis with the property shock.

The paper contributes to three strands of literature. It extends the work on the calibration of the Solvency II market risk module (Höring 2013; Braun, Schmeiser and Schreiber 2015, 2017; Fischer and Schlütter 2015) by providing the first country-level evidence for the property shock based on market data. It applies the literature on appraisal smoothing (Geltner 1991, 1993; Quan and Quigley 1991; Fisher, Geltner and Webb 1994; Clayton, Geltner and Hamilton 2001; Bond, Hwang and Marcato 2012) to a regulatory parameter and shows how much the choice of data matters. And it documents a strong home bias in insurers' property holdings, which turns a question about European averages into one about national tails. Section 2 describes the regulatory treatment of property. Section 3 reviews the literature and derives the hypotheses. Section 4 presents data and methods, Section 5 the structure of insurers' property holdings and Section 6 the tail estimates. Section 7 analyses capital charges and allocation, Section 8 discusses implications and limitations, and Section 9 concludes.

2 Property in the Solvency II standard formula

The market risk module of the standard formula contains separate sub-modules for interest rate, equity, property, spread, currency and concentration risk. The property risk sub-module applies to land, buildings and immovable-property rights (Article 174 of Delegated Regulation (EU) 2015/35). The shock of 25 per cent is applied without differentiation by country, sector or use. Property held for own use is included. Since the standard formula aggregates the sub-modules with a correlation of 0.75 between equity and property risk, the property charge is diversified only to a limited extent.

Indirect holdings are assigned to sub-modules in one of three ways. Shares of listed property companies are equities and are charged 39 per cent for type 1 equities, plus the symmetric adjustment. Units in real estate funds are subject to the look-through approach: the capital requirement is calculated on the basis of the underlying assets (Article 84(1)). Investments in related undertakings are, in principle, charged as equity. Since the amendment by Delegated Regulation (EU) 2019/981, however, the look-through approach also applies to related undertakings whose main purpose is to hold and manage assets on behalf of the participating undertaking, provided that further conditions are met (Article 84(4)). EIOPA has confirmed in its question-and-answer process that property subsidiaries of insurers can fall under this provision (EIOPA Q&A 1856, 2044 and 3226). Their real estate is then charged with the 25 per cent property shock, while the participation remains on the balance sheet as an equity holding. Property held through subsidiaries therefore appears in the reporting data as equity, but it is regulated as property.

The symmetric adjustment moves the equity charge with the market. It is derived from the deviation of an equity index from its three-year moving average and was initially restricted to a corridor of ± 10 percentage points (Article 106 of Directive 2009/138/EC; Article 172 of the Delegated Regulation). When equity markets have fallen, the charge declines, which is intended to prevent pro-cyclical sales. The adjustment does not apply to property. Its changes therefore alter the relative capital cost of holding property through listed shares instead of directly. This relative price is the basis of our test of insurers' allocation in Section 7.

3 Literature and hypotheses

3.1 Calibration of the market risk module

A first strand of literature asks whether the standard formula achieves its target of a 99.5 per cent survival probability over one year and how it affects investment behaviour. Höring (2013) compares the market risk capital of a representative European life insurer under the standard formula and the Standard & Poor's rating model and finds that, for a comparable level of confidence, the rating model requires 68 per cent more capital; the standard formula is therefore unlikely to bind. Braun, Schmeiser and Schreiber (2015) estimate the ruin probabilities implied by the standard formula for mean-variance efficient portfolios and find that they deviate substantially from the regulatory target. In a related study, Braun, Schmeiser and Schreiber (2017) show that the standard formula interferes with economically sensible asset allocation decisions of life insurers. Fischer and Schlütter (2015) demonstrate that a higher stock risk parameter does not necessarily reduce the default probability of a shareholder-value-maximising insurer. These studies take the stress factors as given. Our paper instead re-estimates one of them.

Work on the property factor itself is limited. The calibration by CEIOPS (2010) rests on the monthly IPD UK index, the longest available series. Cullen (2011) and the update by MSCI (2017) use annual valuation-based and transaction-linked indices for several European markets up to 2015. They report 0.5 per cent tail values at risk of transaction-linked indices of − 24.6 per cent for the United Kingdom, but only − 5.8 to − 9.3 per cent for France, Germany, the Netherlands, Sweden and Switzerland and − 11.2 per

cent for a pan-European composite (MSCI 2017, Exhibit 10). Durán Santomil et al. (2019) apply several de-smoothing techniques to the IPD UK monthly index for 1986 to 2009 and find capital requirements that are generally higher than 25 per cent. Barañano, De La Peña and Moreno (2020) propose a Monte Carlo value-at-risk model for Spanish residential property. To our knowledge, no study has used market prices of listed property companies to assess the property shock across countries.

3.2 Appraisal smoothing and listed property

Appraisal-based indices are smoother than the underlying market values because appraisers update their estimates only partially and with a lag. Quan and Quigley (1991) show that partial adjustment can be rational given noisy transaction information. Geltner (1991, 1993) models the appraised value as a weighted average of the current market value and the previous appraisal, which motivates first-order autoregressive de-smoothing. Fisher, Geltner and Webb (1994) compare index construction methods, and Clayton, Geltner and Hamilton (2001) find smoothing at the level of individual appraisals. Bond, Hwang and Marcato (2012) caution that the autoregressive filter applied to indices can overcorrect, because smoothing at the asset level and aggregation in the index have different effects; Delfim and Hoesli (2021) propose robust alternatives. In accounting, the fair values of investment property under IAS 40 are typically based on external appraisals; Dietrich, Harris and Muller (2000) and Muller, Riedl and Sellhorn (2011) examine their reliability and information content.

Listed property companies provide a market-based alternative. Their share prices incorporate information earlier than appraisals (Barkham and Geltner 1995) but also reflect leverage, financial distress and general equity market sentiment. Sun, Titman and Twite (2015) show that, during the financial crisis, share prices of US real estate investment trusts fell much more than the prices of the underlying properties and that the decline was larger for trusts with higher leverage and shorter debt maturity. Unlevering removes the mechanical effect of leverage, but not distress costs or sentiment. Market-based estimates are therefore an upper benchmark for the risk of a well-diversified property portfolio, and appraisal-based estimates a lower one.

3.3 Hypotheses

The calibration of a value-at-risk measure on smoothed data understates volatility and tail losses. Our first hypothesis is therefore that raw appraisal-based measures understate the one-year tail risk considerably, whereas de-smoothed and market-based measures are close to the 25 per cent calibrated on UK data (H1). Because insurers' direct holdings are domestic, the relevant risk is national. National property markets differ in their cycles, financing structures and valuation practices; we expect the national tail estimates to vary widely around 25 per cent (H1a). A 1-in-200 loss estimated from about twenty-five years of data is determined by the worst episode in the sample. We therefore expect the estimates to depend heavily on whether the 2008/09 crisis is included and to be imprecise (H1b). Finally, if insurers optimise capital costs at the margin, a lower equity charge should make listed property shares relatively more attractive than direct property. We test whether changes in the symmetric adjustment lead to reallocations between the two (H2).

4 Data and methods

4.1 Insurers' property holdings

Holdings are taken from the public aggregates of the Solvency II quantitative reporting templates published by the European Insurance and Occupational Pensions Authority (EIOPA). The exposure data based on the list of assets (S.06.02) are available quarterly from 2017 Q4 to 2026 Q2 by reporting country, undertaking type, complementary identification code (CIC) category and location of investment. We exclude unit-linked and index-linked portfolios, where the investment risk is borne by policyholders. We distinguish four categories: direct investment property (CIC 9 excluding own use), property for own use, real estate funds (CIC 4, sub-category 5) and equity of real estate related corporations (CIC 3 − 2). For the composition of equity holdings, we use the aggregate balance sheet (S.02.01). The symmetric adjustment is taken from EIOPA's monthly technical information.

4.2 Appraisal-based returns

Our appraisal-based measure is the annual revaluation rate of investment property reported by European listed property companies under IAS 40, defined as the fair-value gain or loss on investment property divided by its prior-year carrying amount. Firm-level data from LSEG Datastream cover 390 companies with 3,891 firm-years from 2003 to 2026. To reduce noise, we use the median revaluation rate per country and year, requiring at least three firms, and retain countries with at least nine years. This gives 250 country-years from 14 countries. The revaluation rate measures changes in capital value only and excludes income. It therefore corresponds directly to the instantaneous value shock of Article 174.

Following Geltner (1993), we model the observed rate r^*_t as a partial adjustment to the unobserved market rate r_t, $r^*_t = (1 - \varphi)\, r_t + \varphi\, r^*_{t-1}$, and recover $r_t = (r^*_t - \varphi\, r^*_{t-1})/(1 - \varphi)$. We estimate φ by a pooled first-order autoregression of country-year median revaluation rates for 2006 to 2025 with country fixed effects and standard errors clustered by country. The estimate is $\varphi = 0.43$ ($t = 6.9$). Country-by-country estimates are imprecise and range from 0.04 to 0.80; their median is 0.34. Because the within estimator of an autoregressive coefficient is biased downwards in short panels (Nickell 1981), we also report results for a bias-corrected value of 0.52. We use 0.43 as our main value and 0.34 and 0.52 as bounds.

4.3 Market-based returns

The market-based measure uses weekly total return indices in local currency for 893 European listed property companies, including companies that were delisted during the sample period, from January 2002 to November 2026. Weekly returns are winsorised at ± 50 per cent. We unlever each company's equity return with its market leverage at the end of the previous year, $L = D/(D + E)$, where D is total debt and E is the market value of equity, capped at 0.9. In the main specification, the asset return is $r_t = (1 - L)\, r_t$, which assumes that the market value of debt is constant. Two variants allow for changes in the value of debt, $r_t = (1 - L)\, r_t + L\, r_t$. In the first, r_t reflects only changes in interest rates: it is derived from local ten-year government bond yields with a constant spread of 1.5 per cent and a duration of five years. In the second, r_t is the weekly total return of the iBoxx € Corporates BBB index (for the United Kingdom, the

iBoxx £ Corporates BBB index), which also captures changes in credit spreads. Since 2014, its weekly returns have a correlation of 0.91 with those of an index of euro-denominated real estate bonds.

We aggregate the unlevered returns into equal-weighted and value-weighted portfolios, the latter weighted by prior-year market capitalisation, requiring at least five companies per week. We then compound the weekly portfolio returns to rolling 52-week returns and take the empirical 0.5, 1 and 5 per cent quantiles. This replicates the method of CEIOPS (2010), which used rolling twelve-month returns. National portfolios are formed for the twelve countries with sufficient coverage. One methodological point deserves emphasis. A chained cross-sectional median of weekly returns, a seemingly robust alternative, is not a portfolio: the median removes the common component of returns in volatile weeks and halves the volatility of the resulting index. In our data, the standard deviation of rolling 52-week returns is 4.9 per cent for the chained median, compared with 11.1 per cent for the equal-weighted portfolio. We therefore use portfolios throughout.

With overlapping windows, the 1,246 rolling returns contain information on only about 24 non-overlapping years. The empirical 0.5 per cent quantile is therefore close to the worst window in the sample. We assess its sensitivity in two ways: by excluding windows ending between January 2008 and June 2010, and by a moving-block bootstrap of weekly portfolio returns with a block length of 52 weeks and 1,000 replications, from which we report 90 per cent intervals.

5 How European insurers hold real estate

Table 1 shows the four categories of property holdings as a share of investments excluding unit-linked business. Total holdings increased from 4.8 per cent (EUR 322 billion) at the end of 2017 to 6.8 per cent in 2022 and then declined to 6.0 per cent (EUR 421 billion) at the end of 2025. The composition has changed: direct investment property fell from 1.6 to 1.3 per cent, whereas real estate funds rose from 1.6 to 2.5 per cent and property equity from 1.3 to 1.8 per cent. Property for own use is stable at about 0.4 per cent. Insurers have thus shifted from direct ownership to indirect holdings.

Table 1
Real estate holdings of EEA insurers, % of investments excluding unit-linked

Q4	Direct (investment)	Direct (own use)	Funds	Property equity (CIC 3 − 2)	Total	Total (EUR bn)
2017	1.6	0.3	1.6	1.3	4.8	322
2018	1.6	0.4	1.8	1.4	5.2	348
2019	1.5	0.4	1.9	1.5	5.2	383
2020	1.4	0.4	2.0	1.5	5.3	397
2021	1.5	0.4	2.2	1.7	5.8	437
2022	1.7	0.5	2.7	1.9	6.8	435
2023	1.5	0.4	2.6	1.7	6.3	419
2024	1.5	0.4	2.6	1.7	6.2	420
2025	1.3	0.4	2.5	1.8	6.0	421

Note: Direct (investment) = CIC 9 excluding own use; funds = CIC 4, sub-category 5; property equity = CIC 3 − 2, equity of real estate related corporations. Source: EIOPA, S.06.02 aggregates.

Table 2 shows large differences across the fourteen largest insurance markets. Austrian insurers hold 9.1 per cent of their investments in direct property, Spanish and Belgian insurers around 2.5 per cent, and Italian and Irish insurers less than 0.5 per cent. Dutch insurers invest mainly through funds (5.7 per cent), and Norwegian, Portuguese and Swedish insurers through property equity (9.1, 6.8 and 4.8 per cent). The home share of direct investment property is 94 per cent for the EEA as a whole and exceeds 90 per cent in eight of the fourteen countries; it is 97 per cent in Germany, 94 per cent in France and 100 per cent in Austria and the Netherlands. Substantial foreign holdings are found only in Belgium, in the cross-border markets of Luxembourg and Ireland and in Norway and Poland. Property equity is also domestic (92 per cent), in contrast to common equity (63 per cent; Table 6). The relevant risk for most insurers is therefore that of a single national property market.

Table 2
Real estate holdings by reporting country, 2025 Q4, % of investments excluding unit-linked

Country	Direct (investment)	Direct (own use)	Funds	Property equity	Home share of direct	Investments (EUR bn)
France	1.0	0.3	2.9	2.2	93.7	2,209
Germany	1.1	0.4	2.9	1.3	97.3	2,019
Italy	0.5	0.3	2.5	0.3	98.0	787
Netherlands	1.3	0.1	5.7	0.2	100.0	314
Denmark	2.0	0.1	2.0	3.1	91.2	285
Belgium	2.4	0.5	0.9	2.2	73.4	264
Spain	2.6	1.1	0.3	0.5	98.8	261
Sweden	2.0	0.6	0.6	4.8	89.1	171
Norway	0.2	0.1	1.0	9.1	36.8	159
Ireland	0.1	0.6	0.9	0.3	75.1	117
Austria	9.1	1.2	0.2	3.9	100.0	112
Luxembourg	0.4	0.4	1.0	0.6	12.5	85
Poland	0.3	1.6	1.5	0.3	42.0	43
Portugal	0.9	0.6	0.6	6.8	97.1	37

Note: Fourteen largest markets by investments excluding unit-linked. Home share = % of direct investment property located in the reporting country (EEA: 94%). Source: EIOPA, S.06.02 aggregates.

6 Tail risk of property: appraisal versus market

6.1 Europe

Table 3 compares the quantiles of one-year returns from the different sources. Raw appraisal-based revaluation rates imply a 0.5 per cent quantile of − 11.2 per cent, less than half of the regulatory shock. De-smoothing with φ = 0.43 doubles the tail loss to − 22.7 per cent; the bounds of φ give − 19.1 and − 27.2 per cent. A country bootstrap yields a 90 per cent interval of − 23.8 to − 18.4 per cent for the main value. De-smoothed appraisal data thus come close to the 25 per cent. The market-based measures are more severe. The 0.5 per cent quantile of rolling 52-week unlevered returns is − 30.3 per cent for the equal-weighted and − 32.8 per cent for the value-weighted European portfolio. The differences between the measures diminish further out in the distribution: at the 5 per cent quantile, de-smoothed appraisal data give − 12.4 per cent and market data − 18.0 and − 20.8 per cent.

Table 3
Quantiles of one-year real estate returns, Europe (%)

Measure	Observations	N	0.5%	1%	5%
Appraisal-based, raw	country-years	250	−11.2	−10.8	−7.5
Appraisal-based, de-smoothed, φ = 0.34	country-years	250	−19.1	−17.0	−11.0
Appraisal-based, de-smoothed, φ = 0.43 (main)	country-years	250	−22.7	−19.7	−12.4
Appraisal-based, de-smoothed, φ = 0.52	country-years	250	−27.2	−24.3	−14.8
Market-based, unlevered, equal-weighted	rolling 52 weeks	1246	−30.3	−29.4	−18.0
Market-based, unlevered, value-weighted	rolling 52 weeks	1246	−32.8	−31.3	−20.8

Note: Appraisal-based: median IAS 40 revaluation rate per country-year (at least 3 firms; 14 countries with at least 9 years), de-smoothed as $r = (r^* - \varphi r^*_{-1})/(1 - \varphi)$. Market-based: rolling 52-week returns of portfolios of European listed property companies, unlevered with prior-year market leverage, 2002–2026. Solvency II shock: −25%.

Accounting for the market value of debt changes the market-based results in both directions (Table 4, last two columns). If only interest rates are considered, falling yields in crises raise the value of debt and lower the implied asset loss to − 27.5 per cent. If the debt return is taken from BBB corporate bond indices, the widening of credit spreads dominates, and the loss rises to − 32.8 per cent (equal-weighted) and − 35.0 per cent (value-weighted). With a median market leverage of 0.51 before the crisis and a duration of five years, each percentage point of spread widening adds about 2.5 percentage points to the asset loss. The constant-debt specification thus lies between the two variants.

The evidence supports H1 with one qualification. Raw appraisal data understate the tail risk of property by about half, as the literature on smoothing suggests. De-smoothed data are close to 25 per cent, and market data exceed it by 5 to 10 percentage points. The industry position of a shock of at most 15 per cent (Cullen 2011; MSCI 2017) is consistent with raw appraisal data, but not with de-smoothed or market-based evidence.

6.2 National markets

Figure 1 and Table 4 show the national estimates. The equal-weighted 0.5 per cent quantile ranges from − 9.3 per cent in Switzerland and − 12.2 per cent in Belgium to − 40.5 per cent in Norway and − 45.9 per cent in the United Kingdom. Seven of the twelve countries exceed 25 per cent in equal-weighted portfolios and ten in value-weighted portfolios; only Switzerland and France remain below the shock in both. The value-weighted results are more extreme in markets dominated by a few large companies, notably Austria (− 64.3 per cent) and Italy (− 46.9 per cent). For Germany, the market estimate (− 23.7 and − 28.1 per cent) is about four times the transaction-linked value of MSCI (2017), and for France

about twice as large (− 18.9 per cent compared with − 8.1 per cent). For the United Kingdom, MSCI's value of − 24.6 per cent is close to the regulatory shock, whereas the market estimate is almost twice as high.

Table 4
0.5% quantile of rolling 52-week unlevered returns by country (%)

Europe	Firms	EW	EW CI90	VW	EW excl. 2008/09	VW excl. 2008/09	EW, debt: rates	EW, debt: iBoxx
	893	**−30.3**	**[− 31.3; −9.0]**	**−32.8**	**−10.5**	**−20.6**	**−27.5**	**−32.8**
Germany	148	−23.7	[− 27.3; −15.2]	−28.1	−22.1	−28.0	−22.3	−25.9
United Kingdom	178	−45.9	[− 49.1; −20.2]	−39.9	−20.9	−27.2	−43.7	−48.7
France	107	−18.9	[− 21.8; −5.2]	−23.1	−5.6	−19.5	−15.8	−21.3
Sweden	78	−34.7	[− 39.8; −14.4]	−31.3	−21.5	−30.5	−31.5	−37.1
Spain	120	−37.2	[− 36.5; −13.6]	−37.9	−19.3	−18.6	−34.9	−39.7
Belgium	48	−12.2	[− 16.8; −6.1]	−27.1	−8.6	−27.2	−10.5	−12.8
Switzerland	37	−9.3	[− 14.9; −3.7]	−15.9	−4.9	−8.5	−6.6	−12.6
Netherlands	29	−36.7	[− 38.9; −14.7]	−35.5	−16.5	−26.5	−33.9	−37.7
Norway	24	−40.5	[− 41.8; −16.0]	−33.0	−20.9	−21.2	−38.0	−42.4
Austria	13	−39.7	[− 43.8; −11.8]	−64.3	−12.7	−21.0	−36.6	−41.9
Italy	27	−36.5	[− 38.9; −22.1]	−46.9	−27.9	−27.7	−33.7	−38.5
Finland	13	−24.4	[− 27.2; −7.9]	−25.0	−8.4	−17.6	−21.3	−26.3

Note: EW = equal-weighted, VW = value-weighted (prior-year market capitalisation). CI90 = 90% interval from a moving-block bootstrap of weekly EW returns (block length 52 weeks, 1,000 replications). Excl. 2008/09 drops windows ending January 2008 to June 2010. Debt variants: r□ = (1 − L) r□ + L r□; rates: r□ from local 10-year government yields, constant spread 1.5%, duration 5; iBoxx: r□ = total return of iBoxx € Corporates BBB (UK: iBoxx £ Corporates BBB). Data: LSEG Datastream.

The national spread is consistent with H1a. A single factor of 25 per cent overstates the risk of Swiss, French and Belgian property and understates that of British, Scandinavian and Southern European property. Since insurers hold their property at home, the uniform factor does not correspond to the risk of most individual portfolios, even if it is close to the European average.

6.3 The weight of a single crisis

Figure 2 shows the rolling 52-week returns of the European portfolios. Only the windows ending between late 2008 and mid-2009 fall below − 25 per cent; the next most severe episode, in 2022/23, reached − 11.3 per cent (equal-weighted) and − 23.8 per cent (value-weighted). Excluding windows that end between January 2008 and June 2010 reduces the European 0.5 per cent quantile to − 10.5 per cent (equal-weighted) and − 20.6 per cent (value-weighted; Table 4). Without 2008/09, only Italy exceeds 25 per cent in equal-weighted portfolios, and six of twelve countries in value-weighted portfolios. The moving-block bootstrap confirms the fragility. The 90 per cent interval for the European equal-weighted quantile ranges from − 31.3 to − 9.0 per cent; the point estimate is close to its lower bound because resamples that contain the crisis block reproduce it, while those that do not yield much smaller losses. National intervals are similarly wide, for example − 49.1 to − 20.2 per cent for the United Kingdom and − 21.8 to − 5.2 per cent for France.

H1b is therefore supported. This finding has a different implication from what it may seem to suggest. A 1-in-200 event is by definition rare, and the 2008/09 crisis is the only event in our sample that comes close to it. Excluding it would calibrate a 99.5 per cent measure on what are at most 1-in-25 events. The appraisal-based results are less sensitive (− 18.3 per cent without 2008/09 after de-smoothing), because smoothing spreads the crisis over several years. The 25 per cent of CEIOPS (2010) is also essentially determined by the UK crisis of 2007 to 2009, as the tail values reported by MSCI (2017) for the United Kingdom show: they moved from + 1.4 to − 22.9 per cent when 2008 was added to the sample. What the data can establish is the order of magnitude of a severe crisis, not a precise quantile.

7 Capital charges, look-through and allocation

If the standard formula steers investment, the symmetric adjustment should shift holdings between listed property equity, which carries the equity charge, and direct property, which carries the property charge. We test this with a panel of the twenty largest reporting countries from 2017 Q4 to 2026 Q2. The dependent variables are the net flow into property equity (the change in holdings minus the return of the equal-weighted European listed property portfolio), the growth of direct property and the change in the log ratio of property equity to direct property. The explanatory variable is the symmetric adjustment at the end of the previous quarter. All regressions include country fixed effects and the growth of total investments; standard errors are clustered by quarter.

Table 5
Symmetric adjustment of the equity charge and insurers' real estate allocation

Dependent variable	Symmetric adjustment (t − 1)	t	N
Net flow into CIC 3 − 2 (quarterly)	0.139	1.1	662
Growth of direct property	0.048	1.0	662
Δ log(CIC 3 − 2 / direct)	−0.003	−0.0	662

Note: Country-quarter panel, 20 largest markets, 2017 Q4–2026 Q2, 34 quarters. Country fixed effects; control for total investment growth (and the listed property return in the mix regression); standard errors clustered by quarter. Net flow = change in holdings minus the return of the equal-weighted European listed property portfolio.

Table 5 shows no effect. The coefficients are small and insignificant (t = 1.1, 1.0 and − 0.0). H2 is not supported. Table 6 explains why this is not surprising. The equity holdings of EEA insurers in S.06.02 total EUR 1,237 billion, of which EUR 126 billion are property equity (CIC 3 − 2). In the balance sheet, however, holdings in related undertakings, including participations, amount to EUR 1,166 billion, compared with only EUR 147 billion of listed equities. If CIC 3 − 2 consisted of listed shares, it would account for 86 per cent of all listed equities held by insurers, which is implausible. Together with the domestic share of 92 per cent, this indicates that property equity consists mainly of participations in domestic property subsidiaries. Under Article 84(4) of the Delegated Regulation, such subsidiaries are treated on a look-through basis and their property is charged at 25 per cent. The symmetric adjustment does not affect them.

Table 6
Composition of insurers' equity holdings, EEA, 2025 Q4

Item	EUR bn	Home share (%)
S.06.02 – equity (CIC 3), total	1,237	66.4
of which real estate related corporations (CIC 3 − 2)	126	92.1
of which common equity (CIC 3 − 1)	1,047	62.9
S.02.01 – holdings in related undertakings, incl. participations	1,166	–
S.02.01 – equities – listed	147	–
S.02.01 – equities – unlisted	66	–
S.02.01 – property (other than for own use)	89	–

Note: S.06.02: list of assets, portfolios excluding unit-linked; S.02.01: balance sheet, all undertakings (solo). Source: EIOPA.

Two conclusions follow. First, the property shock applies to a much larger base than direct holdings suggest. Together with funds treated on a look-through basis and subsidiaries, up to about 6 per cent of

investments is capitalised with the 25 per cent factor, compared with 1.7 per cent held directly. Second, the reporting categories are a poor guide to regulatory treatment. Analyses of insurers' asset allocation under Solvency II that treat CIC 3 as listed equity overstate the role of equity markets and understate that of property.

8 Implications and limitations

Our results have three implications for the calibration of the property shock. First, the level is not too high. De-smoothed appraisal data and market data imply a European tail loss of 23 to 35 per cent, and the industry proposal of 15 per cent is consistent only with raw appraisal data that understate volatility. Recalibrating the shock downwards on the basis of valuation indices would repeat the error that CEIOPS (2010) made when it accepted smoothed data and avoided it only because the UK series it used was particularly volatile. Second, the uniform factor is a poor fit for individual insurers. With a home share of 94 per cent, the risk of an insurer's property portfolio is the risk of its national market, which ranges from about 10 to about 45 per cent. Country-specific factors, or a concentration add-on for undiversified national portfolios, would bring the standard formula closer to the 99.5 per cent target. Insurers with concentrated portfolios in volatile markets could also be expected to address this in their own risk and solvency assessment. Third, the evidence for any specific number is weak because it rests on one crisis. Supervisors should treat the 25 per cent as an expert judgement of the size of a severe crisis, informed by data, rather than as an estimated quantile, and they should test it against several crisis scenarios rather than a single historical sample.

The study has several limitations. Listed property companies are not identical to insurers' portfolios: they hold more development and commercial property, their share prices contain equity market sentiment, and unlevering removes only the mechanical effect of debt. Our market estimates are therefore an upper benchmark. The appraisal-based estimates depend on the de-smoothing model, whose limitations are well documented (Bond, Hwang and Marcato 2012; Delfim and Hoesli 2021). We use country medians and a common smoothing parameter because country-specific estimates are unstable. We do not have access to private transaction-based indices for all countries and cannot distinguish residential from commercial property consistently. The reporting data are aggregates; we cannot observe individual insurers' portfolios or their treatment under internal models. Finally, the regression in Section 7 has limited power, and the absence of an effect is consistent with the regulatory treatment rather than proof of insurers' indifference to capital costs.

9 Conclusion

The Solvency II property shock of 25 per cent was derived from appraisal-based UK data and has been criticised by the industry as too high. Using reporting data, IAS 40 revaluations and market prices of listed property companies, we show that it is roughly right for Europe on average, too low for most national markets and much higher than raw appraisal data suggest. Because insurers hold their property at home, the national dispersion matters more than the European average. All estimates depend on the

2008/09 crisis and are imprecise, which argues for treating the calibration as a scenario judgement rather than a statistical quantile. Finally, insurers' property equity is mostly held through subsidiaries that are regulated as direct property, so that the property shock governs a larger part of their investments than the reporting categories show.

Declarations

Author Contribution

The author confirms sole responsibility for the following: study conception and design, data collection, analysis and interpretation of results, and manuscript preparation.

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During the preparation of this work we used Claude (Opus 5.5, Anthropic) in order to improve the language and readability of the manuscript and to restructure selected passages. After using this tool, we reviewed and edited the content as needed and take full responsibility for the content of the published article.

Data Availability

The data were obtained from LSEG Datastream and Worldscope under licence.

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Figures

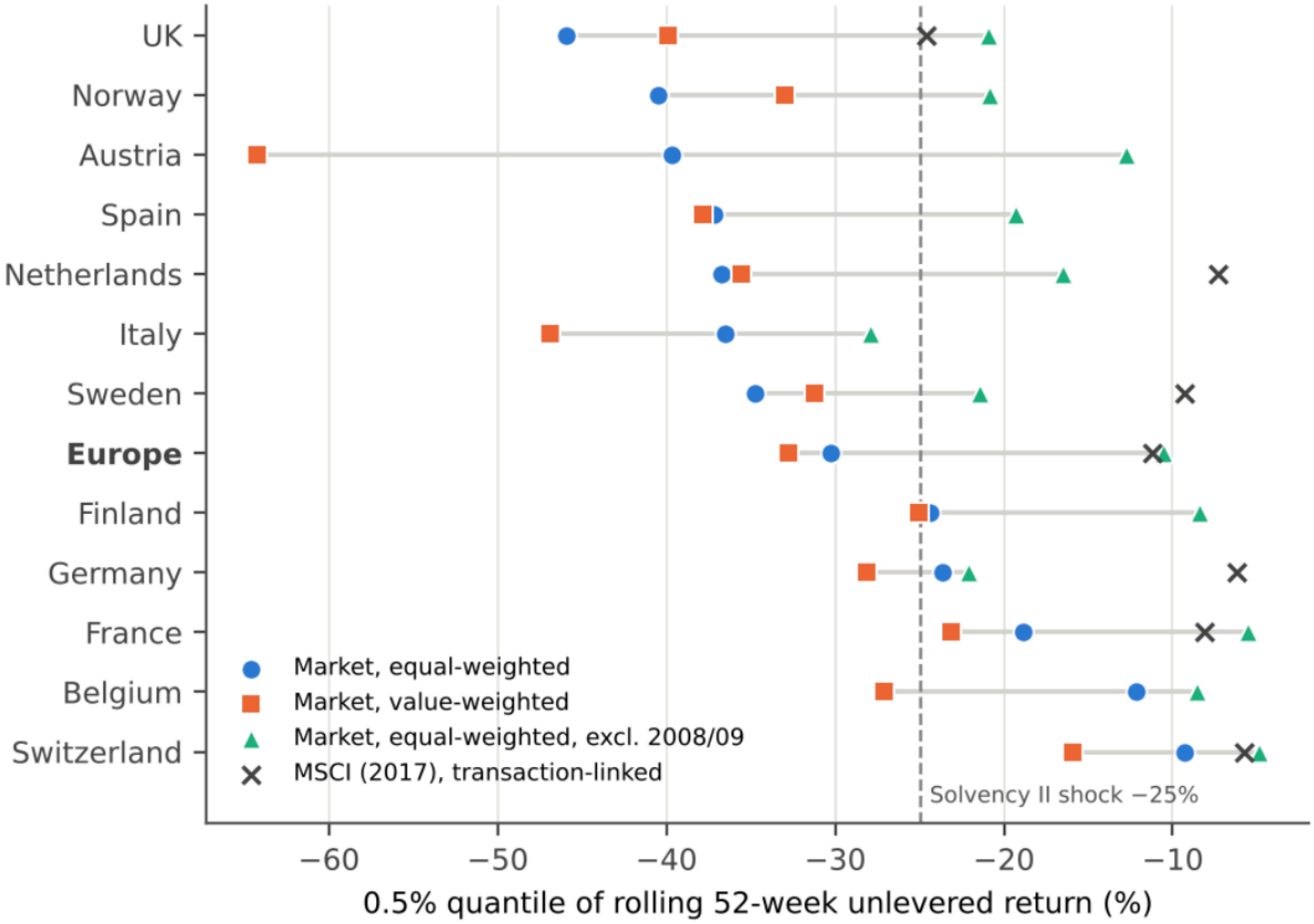


Figure 1

0.5 per cent quantile of rolling 52-week unlevered returns of listed property portfolios by country. Equal-weighted and value-weighted portfolios of European listed property companies, unlevered with prior-year market leverage, 2002–2026; triangles exclude windows ending January 2008 to June 2010. Crosses: 0.5 per cent tail value at risk of transaction-linked indices to 2015 (MSCI 2017, Exhibit 10). Dashed line: Solvency II property shock.

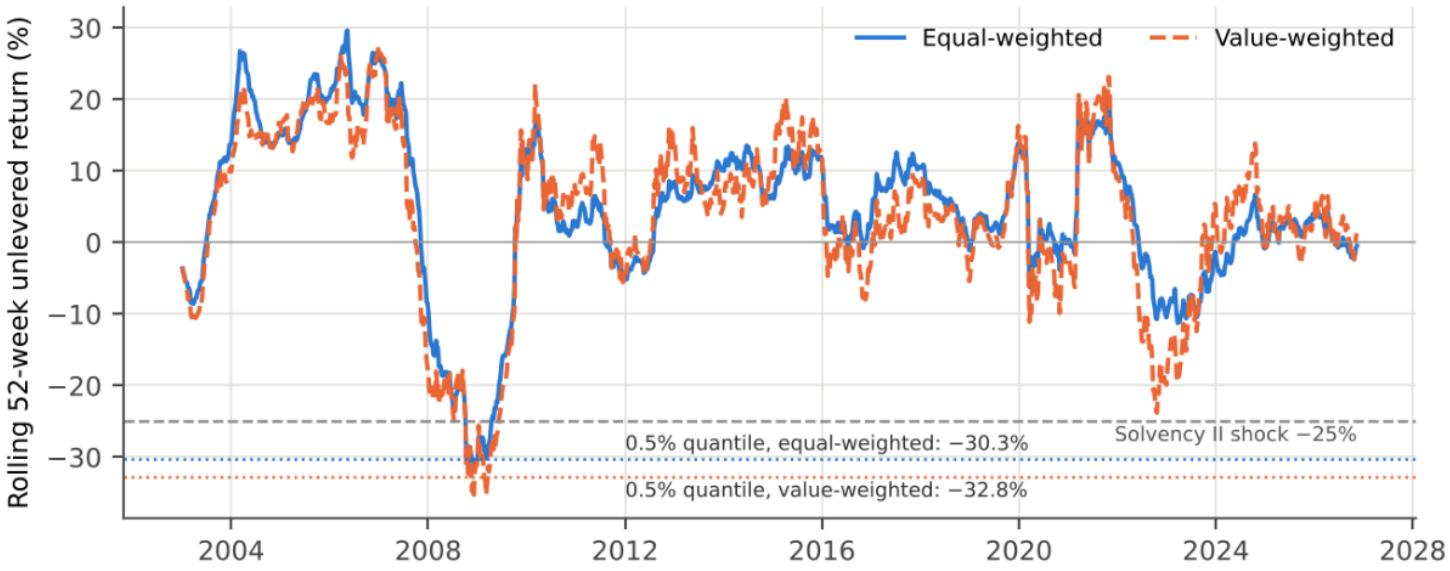


Figure 2

Rolling 52-week unlevered returns of European listed property portfolios. Equal-weighted and value-weighted portfolios of 893 European listed property companies, unlevered with prior-year market leverage. Dotted lines: 0.5 per cent quantiles; dashed line: Solvency II property shock.