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Longevity Insurance

for the Irish ARF and vested-PRSA market

Reserving, pricing and consumer fairness under Solvency II

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Paper — Longevity Insurance for the Irish ARF and vested-PRSA market	3.1.0
Annex A — Stochastic Mortality Projection Pack	2.0.0
Annex B — Full pricing and reserving surface	2.1.0
Annex C — Primary sources	2.0.0
Annex D — Workbook Guide	1.0.1

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Paper classification

Field	Detail
Series	Mylife.ie Working Paper Series
Reference	MWP-2026-04
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Type	Product-design analysis with quantified reserving and capital assessment
Stance	Neutral technical assessment. No commercial recommendation is sought or offered; the paper specifies a design, analyses it, and reports what the analysis shows.
Companion artefact	`MWP-2026-04_Audit_Workbook_v14.2.0.xlsx` — 45 sheets, 76,434 formulas, 50 registered figures; no computed value that is not a live formula
Annexes	A — stochastic mortality projection pack · B — full pricing and reserving surface · C — primary sources · D — workbook guide. Published alongside this paper together with the workbook.
Basis date	31 May 2026
Regulatory basis	Solvency II current rules: Directive 2009/138/EC; Commission Delegated Regulation (EU) 2015/35 — risk margin per Directive Article 77(5) and Regulation Articles 37–39; longevity stress Article 138; life-expense stress Article 140; lapse stress Article 142. Delegated Regulation (EU) 2026/269 treated as a forward look.
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Abstract

A regular-premium deferred whole-of-life annuity, written inside the Irish ARF or vested-PRSA wrapper and priced on a mutualised basis — premiums forfeited on death or lapse before vesting recycle to the surviving pool — is specified, priced, reserved and capital-tested under current-rules Solvency II. The pricing works: the pool balances exactly, the accumulated fund exceeds the reserve at vesting, and the product delivers late-life income no unsecured drawdown strategy can match. Two constraints then bind, in opposite directions. Consumer fairness fails narrowly as marketed — a money's-worth ratio of 0.8952 against a 0.90 floor — and is repaired by resizing distribution to the contract, at a capital cost of €253 per policy. The capital requirement does not repair: holding SCR coverage at every valuation date requires €36,780 of day-one own funds per policy against a lifetime margin of €3,913 — €9.40 of capital per euro of margin — and every available lever fails, because the levers that improve fairness raise the requirement and the levers that reduce the requirement breach fairness. A second, product-independent finding emerges from the reserving work: for this liability profile the Article 138 longevity stress delivers 0.545 of a stochastic 99.5% charge, inadequate in all twenty-seven cells of the pricing panel. The paper concludes the product should not be written on the standard formula as designed, and states precisely why.

Contents

Executive summary · §1 The problem this paper investigates · §2 The product · §3 Pricing basis · §4 Six worked examples · §5 Headline panel · §6 Reserving under Solvency II · §7 Consumer fairness · §8 Findings · §9 Implications · §10 Legal and regulatory framework · §11 Limitations, next steps and verification · §12 Conclusion · Annex register · Disclosures

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Executive summary

The problem. An Irish retiree holding an ARF or vested PRSA bears longevity risk personally. There is no mechanism in the Irish market by which the deep-tail portion of that risk can be transferred at a price the retiree can assess, other than by purchasing an immediate annuity and surrendering the fund. The gap is not one of appetite but of product.

The design examined. A regular-premium deferred whole-of-life annuity written inside the ARF wrapper. The policyholder pays a level premium from a chosen entry age; from a chosen vesting age an escalating income is paid for life. Nothing is payable on death before vesting and there is no surrender value: a dying or lapsing member forfeits their

premiums to the pool, and those forfeitures subsidise the members who reach vesting. That subsidy is the organising idea.

The analysis. The representative case is entry at 65, vesting at 80, a €400,000 fund and a 4% payout. Mortality is ILT17 with Irish insured-lives selection, a CMI_2022-style cohort projection rebuilt from a published Cairns–Blake–Dowd calibration, and a 0.90 self-selection haircut. Discounting uses the EIOPA EUR risk-free curve at 31 May 2026, no volatility adjustment. Capital is assessed on the standard formula with the risk margin at a 6.0% cost of capital (Article 39 of the Delegated Regulation), on a requirement profile computed at every year of the run-off to age 120.

What works. The premium is €12,316.07 per annum, or €1,003.26 monthly on the fully monthly basis. The pool balances exactly: it earns the intended 3% margin to the cent, and at vesting the accumulated fund of €175,975 exceeds the best-estimate reserve of €169,783. Own funds are positive at every date, rising from €3,913 at inception to €6,192 at vesting. The mutualisation subsidy is worth 24.2% of a surviving member's own contribution. Secured income beats the best unsecured drawdown alternative at every age tested; by age 100 the comparator has fallen to €19,060 while the secured income has escalated to €51,059.

What fails, on the consumer side. As marketed — a heaped commission of 100% of the first year's premium plus a 5% trail — the money's-worth ratio is 0.8952 against a 0.90 floor: the premium exceeds the maximum fair premium of €12,250.22 by €65.84. The failure is a distribution loading calibrated to standalone protection business; resizing the trail to 1% restores the ratio to 0.9342 with 3.4 points of headroom, at a capital cost of €253 per policy.

What fails, on the capital side. Holding SCR coverage at 100% at every valuation date requires €36,779.69 of day-one own funds per policy, binding at year eight of the deferral. Against a lifetime margin of €3,913.27 that is €9.40 of capital per €1 of margin — €36.8 million per thousand policies behind €12.3 million of annual premium income. More than half the requirement at inception is the risk margin itself (€20,767.45).

Why the levers do not open. Repricing is unavailable: the fairness floor pins the maximum premium below what capital relief would need, and every uplift tested worsens the ratio monotonically. Longevity reinsurance raises the requirement at every cost tested — €59,179 to €73,065 across an 8–12% swap-cost band — and cannot reach the binding constraint, which sits in the deferral where longevity cannot be ceded by a post-vesting swap; even at zero cost a floor of €27,456 remains. Cheaper distribution improves fairness but raises the requirement, because a lower premium accumulates less. Regulatory reform helps most — the 4.75% post-reform cost of capital reduces the requirement to €32,838, a fall of 10.7%, and moves the binding date from year eight to year ten — but leaves the requirement at 8.4 times the margin.

The finding holds across the surface. The requirement is computed cell by cell for twenty-seven entry-and-vesting combinations. Per unit of benefit it varies by a factor of only 1.64; the representative case sits 10.3% above the panel mean — mid-to-slightly-conservative, not flattering. The Article 138 adequacy verdict is inadequate in all twenty-seven.

The wider finding. For this liability profile the Article 138 longevity stress delivers 0.545 of a stochastic 99.5% charge computed on the same liability. The flat decrement that would reproduce the stochastic charge is 33%, not 20%. That result stands independent of this product and applies to deferred longevity exposure generally.

The conclusion. The product should not be written as designed. The objection is neither prudential nor a defect of pricing: the contract would meet its obligations, the reserve is funded, the mutualisation works, and consumer fairness is achievable on a distribution structure sized to the contract. It is that the capital required to carry deferred longevity risk under the standard formula cannot be serviced by the margin such a contract can generate — and the two constraints that govern the design pull against each other, so no adjustment satisfies both.

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§1. The problem this paper investigates

1.1 The gap in the Irish market

Three decades of Irish pensions policy have transferred longevity risk from institutional balance sheets to individual savers. The Approved Retirement Fund and the vested PRSA leave the retiree holding a fund and a drawdown decision; the imputed-distribution regime obliges a minimum rate of withdrawal; and the only instrument that removes longevity risk — the immediate annuity — removes the fund with it, insuring the whole of remaining life at rates many purchasers decline. The exposure that remains unaddressed is specific: the tail. A healthy 65-year-old faces a cohort life expectancy of 24.1 years on the basis derived in §3, and a material probability of surviving well beyond it. No Irish product pays a scheme-internal income contingent on reaching a chosen late age, funded by affordable premiums during the accumulation years.

1.2 What this paper examines and finds

The paper specifies the natural instrument for that gap — a regular-premium deferred whole-of-life annuity, forfeitable before vesting, mutualised so that forfeitures subsidise survivors — and subjects it to the full discipline a writing office

would face: equivalence pricing with market loadings (§3–§5), Solvency II reserving with the standard-formula stresses and the risk margin (§6), and a consumer-fairness examination with a money's-worth floor and an unsecured-drawdown comparator (§7).

The examination returns one positive and two adverse results. The positive result is that the design is actuarially sound and, to the consumer, genuinely valuable. The first adverse result is a capital requirement out of proportion to the margin the contract can generate, binding inside the deferral, robust across the pricing surface, and unreachable by any tested lever. The second is regulatory rather than commercial: the standard formula's longevity stress, benchmarked against a stochastic 99.5% measure on the same liability, delivers roughly half the charge.

1.3 What the paper contributes

A complete specification and pricing of the mutualised deferred design for the Irish wrapper (§2–§5); a reserving and capital analysis carried to the natural boundary of the question — a day-one own-funds requirement computed at annual resolution over the full run-off, with its binding date, decomposition, and sensitivity to every available lever (§6); a quantified benchmark of Article 138 against a Cairns–Blake–Dowd 99.5% stress on the same liability, at the representative case and across a twenty-seven-cell panel (§6.3–§6.4); a consumer-fairness framework whose binding gate is identified and whose repair is costed (§7); and a fully auditable companion workbook in which every figure in this paper is a live formula, published alongside with four annexes (§11.3).

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§2. The product

2.1 Statement in plain language

The product is a regular-premium deferred whole-of-life annuity, written by an authorised life office and held inside the policyholder's ARF or vested PRSA. Both cashflows are scheme-internal: the pension vehicle pays a level premium to the insurer from entry age until vesting age; from vesting until death the insurer pays an escalating income back into the pension vehicle. If the policyholder dies or lapses before vesting, the policy expires without value — no death benefit, no return of premium, no surrender value. The representative case throughout is entry at 65 and vesting at 80: fifteen years of premiums, then income for life.

2.2 The organising idea

The design is the structural inverse of term assurance. Term assurance pays on death before a boundary; this product pays on survival past one. In both, the counterfactual outcome is premiums paid and no benefit received, and in both, that is the mechanism and not a defect: the premiums of those who do not claim fund the benefits of those who do. Here the mechanism is made explicit as mutualisation. Premiums are counted once, on the date they are paid, and a forfeited premium is not returned — it remains in the pool and funds the survivors' income. A two-policy illustration fixes the accounting: if two members each pay one premium and one lapses after the first year while the other pays a second, the pool has received three premiums; the correct funding base is three, not four. A basis that credited the lapser's premium a second time through a separate forfeiture leg would assume cash that never arrives — one third of the cash actually received, in the illustration. The pricing basis of §3 counts once. Whether the resulting premium is adequate is then settled by the pool's money balance (§8, F1), not by comparison with any reference premium.

2.3 What the product is not

It is not an immediate annuity: income begins at vesting, not purchase. It is not a guaranteed withdrawal benefit: the ARF and the policy are separate assets of the same owner. It is not unit-linked or with-profits: there is no market exposure at any point. It is not a return-of-premium contract: early death or lapse pays nothing, and the price is lower for exactly that reason.

2.4 Wrapper and standing

Both legs pass between the insurer and the pension vehicle; the natural person receives money only through ordinary ARF drawdown, subject to the imputed-distribution rules (§10.3). Two vehicles are in scope, the ARF and the vested PRSA. The minimum economically meaningful deferral emerges from the pricing identity itself rather than by fiat: below a two-year premium term the heaped commission factor reaches the boundary at which no premium solves the identity (§3.1), so the surface is bounded where the product ceases to make sense.

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§3. Pricing basis

3.1 The equivalence identity

The premium solves the classical equivalence identity: the expected present value of premiums, net of the provider

margin and the commission factor, equals the expected present value of income payments plus maintenance expenses, all on the survival-and-persistency-weighted in-force projection of the entering cohort and the risk-free curve of §3.3. Payments are annual in advance in the pricing engine, with a fully monthly engine carried in parallel (§6.6.6). The commission factor is computed per cell rather than taken as a constant, because a heaped payment is a larger share of a short premium base; the identity has no solution once the commission factor reaches one minus the margin, which occurs below a two-year premium term and bounds the feasible surface.

At the representative case the premium is **€12,316.07 per annum**. Two monthly figures attach to it and are not interchangeable: €1,026.34 is the annual premium divided by twelve, and **€1,003.26** is the premium the fully monthly engine prices when payments, decrements and discounting are all genuinely monthly. The difference — 2.25% — is timing, not error, and §6.6.6 decomposes it. Income in this paper is quoted at the vesting date unless stated otherwise; the representative payout of €16,000 per annum (4% of the €400,000 fund) escalates at 2.0% from inception, so its value at vesting is a factor 1.3459 above its inception-dated label at a fifteen-year deferral. Where an inception-dated figure is used it is marked.

3.2 Mortality

The basis is derived, layer by layer, from published sources — never read from a supplied matrix — and every layer is live in the companion workbook:

Layer	Specification
Population base	CSO Irish Life Tables No. 17 (2015–2017), amended edition of 9 November 2020; terminal-age closure by Kannisto logistic to age 120
Insured-lives selection	IILMI annuitant A/E factors (Society of Actuaries in Ireland, 2009–2015 investigation), 0.78 at 60 rising to 1.00 at 95 and above
Self-selection	× 0.90 throughout, reflecting longevity-optimist selection into a contract that pays nothing on early death
Improvement projection	A CMI_2022-**style** cohort projection rebuilt from a published Cairns–Blake–Dowd calibration on England & Wales data: initial improvements from the fitted κ-process, converging by cubic polynomial to a long-term rate that applies to age 85 and tapers to nil at 110. The CMI_2022 model itself is closed-access and is not reproduced; Annex A documents the rebuild and its benchmarking.

The reproduction perimeter is explicit. The rebuilt projection is verified against its published calibration parameters (exactly), against an independently constructed comparator surface carried in the workbook (agreement 4×10^{-8}), and against the calibration's own stress arithmetic (§6.3, §11.3); it is not verified against CMI_2022 outputs, which are closed-access — the "-style" label marks that boundary.

The κ anchor deserves one sentence of provenance, because it is a choice. The projection anchors on the fitted 2022 κ from the Annex A calibration — the pandemic-year diagnostic fit — rather than the trend construction from which Annex A's simulation starts. The sensitivity is quantified in the workbook: on the trend anchor the premium is €5.60 higher (+0.046%), the capital requirement €7.90 higher (+0.021%), and the Article 138 ratio of §6.3 reads 0.542 rather than 0.545. Every verdict in this paper is unchanged on either anchor.

The self-selection haircut is priced as a sensitivity rather than asserted. It is applied once, in the projection layer; removing it entirely (×1.00) lowers the premium 6.2% to €11,559 and the exact requirement 4.5% to €35,116, and moves the money's-worth ratio to 0.894 and the Article 138 ratio of §6.3 to 0.553 — conservative for the writing office in both directions, and no verdict changes.

On this basis the cohort life expectancy at entry is **24.09 years**, and the probability of surviving from 65 to the vesting age of 80 is 0.836 before lapse; 68.8% of the entering pool is still in force at vesting once lapse is included.

3.3 Discounting

The EIOPA risk-free term structure for the euro at 31 May 2026, without volatility adjustment: ultimate forward rate 3.30%, last liquid point 20 years, convergence 40 years, Smith–Wilson α 0.059979, credit-risk adjustment 10 basis points. The workbook transcribes all 150 published spot rates and carries a closed-form Smith–Wilson verification of the extrapolated segment; the monthly engine interpolates discount factors log-linearly between annual nodes at 661 monthly points.

3.4 Loadings

A provider margin of 3.0% of premiums, anchored to the sole computable operating-margin ratio in the Irish SFCR record; a per-policy maintenance expense of €80 per annum at the 2025 base (€82 at the valuation date), inflating at 2.5%; and benefit escalation at 2.0%. Sources for each anchor are given in Annex C.

3.5 Commission and its treatment

The default structure is the one the market writes for protection business: 100% of the first year's premium plus a 5% trail on subsequent premiums. Four further structures are priced in parallel — zero, level 20%, an industry reference (100%, then 20% in years two to four, 3% thereafter), and the right-sized structure derived in §7.6. Commission is a contract cashflow: it enters the best-estimate liability, not only the loading, so every reserving and capital figure in §6

reflects the structure priced.

3.6 Lapse

The documented curve is 5.8% in year one, 3.1% in year two, 1.9% in years three to five, and 1.3% thereafter, ceasing at vesting; a 30% reinstatement rate, derived in the workbook, nets each rate down. Forfeiture is accounted once, per §2.2. Two documented alternates — the curve plus 25 basis points at every duration, and an adverse tripling capped at 11.7% — are carried as sensitivities and do not change any verdict in this paper.

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§4. Six worked cells

Income is quoted at €1,000 per month commencing at the vesting date, the convention of the full surface in Annex B; because the maintenance expense is a fixed euro amount, premiums are not proportional to income and these figures cannot be rescaled by ratio. Ratios in the final column anticipate §6.4: the Article 138 charge as a share of the stochastic charge for that cell.

Cell	Entry	Vest	Monthly premium, as marketed (€)	Right-sized structure (€)	Zero commission (€)	Equivalence only (€)	Art. 138 ÷ CBD 99.5%
Early retiree, modest deferral	60	80	391.74	375.37	341.91	319.56	0.4983
Reference vintage, late vest	65	85	256.41	245.70	223.06	205.67	0.5114
Late retiree, late vest	70	85	379.25	363.40	323.06	302.36	0.5655
Late retiree, early vest	70	75	3,415.80	3,272.17	2,482.68	2,381.83	0.6373
Maximum deferral	60	85	188.53	180.66	166.06	150.39	0.4685
Deep tail	60	90	83.57	80.08	73.98	61.82	0.4303

4.1 Reading the six

The premium falls steeply with deferral — deep-tail cover at entry 60 costs €84 a month as marketed — and rises steeply as the deferral shortens, with the five-year 70/75 cell approaching immediate-annuity territory and included for the boundary rather than as a sale point. The gap between the marketed and equivalence columns is the total loading; the gap between marketed and zero-commission is distribution alone, and it is the subject of §7.6. The representative case of the rest of this paper is entry 65, vesting 80, at full scale: €400,000 fund, 4% payout, premium €12,316.07.

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§5. Headline panel

The monthly premium surface, as marketed, per €1,000 of monthly income at vesting — the seven-by-four slice of the full sixteen-by-sixteen surface in Annex B:

Entry \ Vest	75	80	85	90
60	794.89	391.74	188.53	83.57
63	1,070.58	488.88	225.02	95.87
65	1,362.09	**578.75**	256.41	106.10
68	2,178.38	781.09	319.80	125.81
70	3,415.80	996.60	379.25	143.10
72	7,236.70	1,342.22	461.60	165.27
75	—	2,531.57	662.51	213.46

The panel is monotone in both directions — longer deferrals are cheaper, later entries at a fixed vesting age dearer — and the bold cell is the representative case. Below a two-year premium term the pricing identity has no solution (§3.1); the surface's corner cells at that boundary are infeasible and the full surface in Annex B marks them accordingly.

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§6. Reserving under Solvency II

6.1 Framework

Technical provisions follow Directive 2009/138/EC Article 77 as transposed by S.I. No. 485 of 2015, with the best estimate and risk margin per Articles 38–61 of Delegated Regulation (EU) 2015/35; classified to the life lines of business of Annex I to the Delegated Regulation. The stresses are Article 138 (longevity: a permanent 20% decrease in mortality rates), Article 142 (lapse: the maximum of a +50% increase, a −50% decrease, and a 40% mass-lapse event, each floored at zero), and Article 140 (life expense: a 10% level uplift together with a one-point addition to expense inflation, applied jointly), aggregated with the Annex IV life-underwriting correlations (longevity–lapse 0.25, longevity–expense 0.25, lapse–expense 0.50). The risk margin follows Article 77(5) of the Directive and Articles 37–39 of the Delegated Regulation, at the Article 39 cost-of-capital rate of 6.0% on the run-off SCR strip, computed at every year to age 120.

Stressed best estimates at future dates are renormalised prospectively to the central in-force pool, so each stress is measured on the book as it stands.

6.2 Best-estimate liability

At inception the best estimate is **−€3,913.27** per policy: expected premiums net of margin and commission exceed expected income and expenses, and the buffer sits on the provider side. The sign is correct and it is the margin — own funds at every date equal exactly the present value of the 3% margin on premiums still to come, rising from €3,913.27 at inception to €6,192.45 at vesting, at which point the accumulated fund of €175,975 stands €6,192 above the crystallised reserve of €169,783. Nothing in the adverse findings below stems from a funding deficiency; there is none.

6.3 Article 138 against a stochastic benchmark

Is the standard formula's flat 20% decrement an adequate 99.5% longevity stress for this liability? The question is answered on two criteria, kept deliberately distinct.

The first criterion is distributional and lives in Annex A: where does the 20% decrement fall in the life-expectancy distribution of a Cairns–Blake–Dowd model fitted to England & Wales data (with an Irish parallel)? The answer is age-dependent — the **97.9th percentile at age 65**, the 99.3rd at 75, and the 99.9th at 85 (97.3 / 99.2 / 99.9 on the Irish calibration): short of the 99.5% benchmark at the entry age, adequate to generous at older starting ages.

The second criterion is the one capital is actually set by: apply both stresses to the same liability and compare the charges. On the production basis the CBD 99.5% stress is not flat in age — the stressed-to-central mortality ratio it implies runs from 0.935 at 65 through 0.752 at 80 to 0.576 at 100, against Article 138's 0.80 at every age — and an annuity liability is concentrated precisely at the ages where the stochastic stress is severe and the flat stress is mild. The resulting charge ratio at the representative case is

SCR longevity (Article 138) ÷ SCR longevity (CBD 99.5%) = 0.545.

A multiplier grid in the workbook makes the same point in one line: the flat decrement that reproduces the stochastic charge for this liability is **33%, not 20%** (equivalent multiplier 0.672, interpolated on a grid whose 0.80 column reproduces the Article 138 charge exactly).

Three closely spaced figures reconcile as follows: the ratio is 0.544996 at full precision, quoted as 0.545; on the alternative trend κ-anchor of §3.2 it reads 0.542; without the selection haircut, 0.553. The 99.5% quantile itself derives from the single implementation of Annex A — regenerated bit-for-bit from raw data under fixed seeds — and is triangulated rather than merely reproduced: an independent re-simulation with a different generator and estimator places the Article 138 stress near the 98th percentile at the entry age, and the liability-weighted ratio is independently re-implemented to the same 0.545. The verdict — short of the 99.5% standard at the entry age, inadequate on the charge ratio across the panel — is robust to each of these implementation choices.

The two criteria disagree at the entry age — a life-expectancy-weighted comparison of the stress shifts gives 0.76, while the liability-weighted charge ratio gives 0.545 — and the disagreement is informative, not troubling: life-expectancy weighting counts every future year equally, while the liability weights the years the office must reserve for. The liability-weighted figure governs this paper's verdicts, because it is the one a capital requirement is made of.

6.4 The verdict on the calibration

The charge ratio is computed cell by cell across the twenty-seven-cell panel of §5, under the paper's classifier: inadequate below 0.75, marginal from 0.75 to 0.95, exceeds at 0.95 and above. **Every cell reads inadequate.** The ratio runs from 0.430 at the deepest deferral (entry 60, vesting 90) to 0.683 at the shortest (entry 75, vesting 80), rising as the deferral shortens and never approaching the marginal band. The full panel, with best estimates and charges per cell, is Table B.4 of Annex B. The finding does not depend on this product: any liability concentrated in survival past 80 will find the flat 20% light in the same way, and §9.4 draws the regulatory implication.

6.5 Sub-modules and their treatment

Longevity dominates. Lapse is live only inside the deferral: on a forfeiture design the lapse-up leg reduces the liability and floors at zero, the mass-lapse leg is non-zero only while the best estimate is negative — €1,565.31 at inception, gated to the deferral thereafter — and the down leg carries the residual exposure of members staying to collect. From vesting the premium and forfeiture legs are gone and lapse ceases to be a risk factor. The Article 140 expense stress, at the joint reading stated in §6.1, is an order of magnitude below longevity throughout and is applied on the identical basis in both the annual and the monthly engine. Mortality stress in accumulation benefits the writer of a forfeiture contract and contributes nothing after flooring.

6.6 Own funds, the risk margin, and the requirement

6.6.1 The measure

The paper's capital question is posed as a single number: the day-one own funds per policy that hold SCR coverage at or above 100% at **every** valuation date of the run-off. Own funds at each date are the accumulated net asset value less the central best estimate — equal, on this design, to the margin still to be earned — and the requirement at each date is (aggregate SCR + risk margin − own funds), expressed per policy in force. The reported figure is the maximum of that profile.

6.6.2 Resolution matters

The profile is computed at annual resolution because its peak falls between coarse samples: on a five-point sampling of the run-off the requirement reads €36,744.48; the full annual profile reads **€36,779.69, binding at year eight** — seven years before vesting. The five-point figure survives in the workbook as a labelled legacy comparison; the annual figure is authoritative and is the paper's headline. A fully monthly rebuild of the entire chain — decrements, discounting, premiums, stresses — prices the same requirement at €36,317.92, binding at year ten, 1.26% below the annual figure; the gap decomposes into payment timing (income in twelfths rather than annually in advance is worth −€5,298 of liability), the concentration of the heaped commission at month zero (68% of its present value), and the monthly premium basis itself (−€277). Annual and monthly engines bracket the answer; the paper quotes the annual. The year-eight binding was itself discovered by the move to annual resolution: the earlier five-point grid (years 0, 5, 10, 15, 20) straddles the peak and cannot see it.

6.6.3 What the requirement is made of

At the binding date the requirement per policy in force decomposes — components grossed up by the in-force fraction of 0.826 at year eight — as aggregate SCR €23,125.02, plus risk margin €19,559.86, less own funds €5,905.18: **€36,779.69**. Two features stand out. The risk margin at inception, €20,767.45, exceeds half the whole requirement: the cost of holding capital is of the same order as the capital. And own funds, though always positive, are small against both — which is the finding in miniature. Against the lifetime margin of €3,913.27 the requirement is **€9.40 per €1**; per thousand policies, €36.8 million of day-one own funds behind €12.3 million of annual premium.

6.6.4 The requirement across the surface

The same computation, run cell by cell with each cell's own annual profile, SCR strip and risk margin, gives the capital panel (Table B.6 of Annex B): per €1,000 of monthly income at vesting the requirement spans **€14,154 to €23,251** across all twenty-seven cells — a factor of 1.64 — with a mean of €18,577; the representative case, €20,499, sits 10.3% above the mean. The requirement falls with a longer deferral and, more weakly, with a later entry. The binding duration is not a fixed fraction of the deferral: the ratio of binding year to deferral runs from 0.29 at the shortest deferrals to 0.85 at the longest, rising throughout — which is why the profile must be computed annually, and why the central case's year-eight binding is representative rather than favourable. A single-cell proving block rebuilt independently of the panel machinery reproduces the central cell to €5.28, 0.014%, a documented fixed-expense scaling residual.

6.6.5 Reinsurance

A post-vesting longevity swap — the instrument the market offers — cedes the wrong years. Structure tested: cede the vesting reserve of €169,782.91, pay a swap premium of 10% of ceded (€16,978.29, the centre of the 8–12% band the market prices), and carry a counterparty-default charge of 4% of ceded reserves in place of the ceded longevity SCR. The requirement **rises** to €66,122.18, and moves monotonically across the cost band: €59,179.23 at 8%, €73,065.13 at 12%. Even a costless, charge-free cession of all post-vesting longevity leaves a floor of **€27,456.08**, because the binding constraint sits at year eight, inside the deferral, where longevity cannot be ceded by a post-vesting swap; the theoretical requirement with post-vesting longevity simply deleted is €26,568. The floor is 75% of the unreinsured requirement — retained even at zero cost. Quoted as a running charge, longevity cover costs €214.59 of present value per 20 basis points per annum on the reserve, linearly — a scale the €3,913 margin cannot carry at market prices. Reinsurance, on this design, is not a lever.

6.6.6 Regulatory reform

The risk margin scales linearly in the cost-of-capital rate, so the 2026 reform's reduction from 6.0% to 4.75% is computable exactly: the requirement, re-maximised over the full post-reform profile, falls to **€32,837.52** — 10.7% — and the binding date moves from year eight to year ten, because a smaller risk margin reshapes the profile as well as lowering it. It is the largest single relief available and it leaves the requirement at 8.4 times the lifetime margin. Article 138 itself is unamended by the reform.

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§7. Consumer fairness

7.1 The gates

Three tests are carried through the pricing work. The money's-worth ratio must not fall below 0.90 — the conventional boundary between fair value and materially expensive value for annuity-class products. The premium must be a modest share of the fund it is paid from. And the product must beat the realistic alternative: the same fund, drawn down unsecured, at the ages the product exists to protect. The first test turns out to be the only one that binds, and §7.6 shows both why and what resolves it.

7.2 Premium as a share of fund

The annual premium of €12,316.07 is 3.08% of the €400,000 fund at inception, and the share falls as the fund is drawn: affordability is not at issue anywhere on the surface a purchaser would plausibly occupy.

7.3 The unsecured-drawdown comparator

The structural test asks whether, at the ages that matter, the policyholder receives more with the product than the same fund could deliver without it — against both a minimum-drawdown strategy and strategies deliberately engineered to exhaust the fund at a target age. The workbook's Test C, at the representative case:

Age	Secured income (€)	Best unsecured alternative (€)	Verdict
85	43,764	32,711	pass
90	45,924	32,012	pass
95	48,347	32,171	pass
100	51,059	19,060	pass

The margin widens with age, which is the point: by 100 every engineered drawdown strategy has exhausted and the remaining comparator is the minimum-drawdown path on a depleted fund. The product wins on longevity economics, not on return assumptions — the pool bears the tail so the survivor does not.

7.4 The money's-worth ratio, and why it binds

The money's-worth ratio is the present value of expected income to a policyholder divided by the present value of their expected premiums, both on the mortality-only survival basis — the individual's own actuarial exchange, before the mutualisation subsidy that lapse adds. As marketed, it is **0.8952**: below the 0.90 floor. The ratio is monotone in the premium, so it cannot be repaired upward by charging more, and the workbook's uplift frontier makes the converse point for capital: loading the premium by up to 40% — the direction capital relief would need — drives the ratio monotonically down to 0.639, breaching the floor at every step. Repricing is not available in either direction.

7.5 The maximum fair premium is a fixed quantity

Given the basis, the 0.90 floor pins a maximum fair premium of **€12,250.22**; the marketed premium exceeds it by €65.84. That the design itself is fair-capable is shown at the zero-commission corner, where the ratio is 1.046 — the mutualised exchange returns more than the individual pays, before any distribution cost. The failure is therefore located precisely: it is the distribution loading, calibrated to standalone protection business, applied to an option inside an already-remunerated wrapper.

7.6 Distribution cost, and a structure sized to the product

The commission structure is a design variable with two opposing effects: cutting it improves the money's-worth ratio, and raises the capital requirement — because a smaller premium accumulates less through the deferral. The workbook prices the trade explicitly. Requirements are computed exactly at the two ends of the candidate set — the current design and the recommended structure — and interpolated between them; the interpolation is accurate to ±€0.49 across the table. Requirements here are on the annual-maximum basis of §6.6.2 — the superseded sampled basis reads about €35 lower per row, so a cross-edition comparison shifts by basis before anything else; the recommended row's + €252 is the interpolated figure, its exact recomputation following the table.

Year-1	Trail	Commission factor	Premium (€ p.a.)	MWR	Headroom (pts)	Requirement (€)	Capital cost (€)	Verdict
100%	5.0%	13.97%	12,316.07	0.8952	−0.48	36,779.69	—	outside the constraint (current design)
100%	4.5%	13.52%	12,249.27	0.9001	+0.01	36,812.37	+33	on the boundary — no space
100%	3.0%	12.16%	12,053.15	0.9147	+1.47	36,908.32	+129	clear
100%	2.0%	11.25%	11,925.85	0.9245	+2.45	36,970.59	+191	clear
100%	**1.0%**	**10.35%**	**11,801.22**	**0.9342**	**+3.42**	**37,031.56**	**+252**	**recommended**
100%	0.5%	9.89%	11,739.87	0.9391	+3.91	37,061.57	+282	clear
50%	2.5%	6.98%	11,360.39	0.9705	+7.05	37,247.23	+468	clear (reduced heap)
50%	1.0%	5.63%	11,191.50	0.9851	+8.51	37,329.85	+550	clear

An exact re-computation of the recommended structure — its own SCR strip and risk margin, not the interpolation — prices the capital cost at **€253.05**, of which €1.18 is second-order beyond the interpolated €251.87, and moves the binding date from year eight to year nine. Two adjacent levers are priced for completeness. The provider margin is

repriced at each level and is not a capital lever: at a 2% margin the premium falls to €12,169.50 and the money's-worth ratio clears the floor at 0.906, but the requirement rises to €38,992 on the held-duration basis (€38,999 exactly re-maximised) while inception own funds fall to €2,578 — €15.13 of capital per €1 of margin, against €9.40 at the 3% basis and €32.37 at 1%. The ratio steepens as the margin thins because own funds shrink faster than the requirement grows; at a zero margin own funds are zero and the ratio is undefined. And there is no windfall hiding in the forfeiture accounting: own funds at inception equal the provider margin under every structure tested, so the ranking above is economics, not an artefact.

The recommendation — the workbook's 'chosen structure' — is the 100% + 1% row: a rate the market writes, 3.4 points of headroom above the fairness floor, at a capital cost of €253 — 0.7% of the requirement. It repairs the consumer verdict and leaves the capital verdict untouched.

7.7 The fairness verdict

The product is fair to buy on a distribution structure sized to it, and demonstrably valuable at the ages it exists for. As marketed it fails the money's-worth floor narrowly, for a reason that is identifiable, quantified, and repairable at immaterial capital cost. Fairness is not the reason this product cannot be written; §6 is.

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§8. Findings

F1 — The design funds itself. Over the contract the pool receives €130,442 in present value and pays €126,529 — €106,684 of income, €1,623 of expenses, €18,222 of commission — leaving the intended 3% margin to the cent, at exactly the priced premium. Own funds equal that margin at every date, and at vesting the accumulated fund of €175,975 exceeds the crystallised reserve of €169,783 by €6,192. There is no funding deficiency at any point.

F2 — The mutualisation works, and mortality is its larger engine. A surviving member's income is worth 24.2% more than their own contribution — €36,990 at the representative case — funded by forfeitures of which 58.2% arise from death during the deferral and 41.8% from lapse. The design is described in terms of forfeiture on lapse; the arithmetic says it is more a mortality pool than a lapse pool.

F3 — The product beats the realistic alternative where it matters. Secured income exceeds the best available unsecured drawdown at every age from 85 to 100, the margin widening to €51,059 against €19,060 at 100, by which point every engineered drawdown has exhausted.

F4 — Consumer fairness fails as marketed, narrowly, and is remediable. The money's-worth ratio is 0.8952 against a 0.90 floor — €65.84 of annual premium above the maximum fair premium of €12,250.22. The cause is a protection-market distribution loading; retaining the year-one payment and setting the trail at 1.0% restores 0.9342, with 3.4 points of headroom, at an exactly-computed capital cost of €253.

F5 — The capital requirement is out of proportion to the margin. Holding SCR coverage at every valuation date requires €36,779.69 of day-one own funds per policy, binding at year eight of the deferral, against a lifetime margin of €3,913.27: €9.40 per €1, and €36.8 million per thousand policies. More than half of the inception requirement is the risk margin itself. The figure is computed at annual resolution, cross-built monthly (€36,317.92, 1.26% below), and confirmed across a twenty-seven-cell panel on which it varies by only a factor of 1.64 per unit of benefit, the representative case sitting 10.3% above the mean.

F6 — No available lever closes the gap, and the two main levers oppose each other. Repricing is blocked in both directions by the fairness floor. Longevity reinsurance raises the requirement at every tested cost (€59,179–€73,065 across the 8–12% band) and cannot reach the binding constraint, which sits in the deferral; even costless cession leaves €27,456. Cheaper distribution buys fairness and raises the requirement. The cost-of-capital reform is the largest relief — €32,837.52, a fall of 10.7%, binding moving to year ten — and leaves the requirement at 8.4 times the margin.

F7 — The Article 138 longevity calibration understates this liability class. Benchmarked against a CBD 99.5% stress on the same liability, the flat 20% decrement delivers 0.545 of the required charge at the representative case and between 0.430 and 0.683 across all twenty-seven panel cells — inadequate in every one. The stochastic stress is age-dependent where the regulation is flat: its implied mortality ratio runs from 0.93 at 65 to 0.58 at 100, and the flat decrement that would reproduce the stochastic charge is 33%. In life-expectancy space the same stress sits at the 97.9th percentile at age 65, reaching the 99.5% benchmark only at older starting ages. This finding is independent of the product's viability and applies to deferred longevity exposure generally.

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§9. Implications

9.1 For the Irish retirement-income market

The gap the product addresses is real and the design that addresses it is sound: the adverse finding locates the obstacle

in the interaction between a specific liability shape and a specific capital regime, not in demand, pricing, or consumer value. The market consequence is that deep-tail longevity protection for ARF holders will not arrive as a standalone standard-formula product from a single writing office; if it arrives, it will be through a chassis that changes the capital arithmetic — scale, diversification against an existing annuity back-book, or instruments that do not yet exist in the Irish market.

9.2 For a writing office

Three practical points follow from the machinery. First, the standard formula is the floor of the problem, not its cause: an internal model faithful to this paper's own benchmark would charge more for longevity, not less, so the infeasibility is not an artefact of formula conservatism. Second, resolution matters — the requirement's peak falls between coarse valuation points, and an office assessing a deferred design on five-year snapshots will understate its capital by design; the profile should be computed at least annually, and a monthly build brackets the answer from below. Third, the reinsurance that would help is deferral-period longevity cover, an instrument the market does not currently write; post-vesting swaps cede the wrong years and, at quoted costs, raise the requirement.

9.3 For consumers and advisers

The consumer arithmetic is favourable and the fairness defect is a structure choice, not a design property: the identical contract passes the money's-worth floor comfortably on a right-sized or fee-based distribution basis. The disclosure obligation runs the other way too — this is a forfeiture contract, and the symmetry with term assurance (§2.2) is the honest frame: most purchasers of either will pay premiums and receive no benefit, and that is the mechanism by which those who need the benefit receive it.

9.4 For the regulator and for policy

Two results are on the record independent of any product decision. The Article 138 flat 20% decrement delivers roughly half of a same-liability stochastic 99.5% charge for deferred longevity concentrated past age 80, because the true stress is age-dependent where the regulation is flat; a calibration review of the longevity sub-module for deferred exposures has quantified support here. And the 2026 cost-of-capital reform, while directionally right for this class, closes about a tenth of the gap it would need to close — the risk margin remains the largest single component of the requirement after reform.

9.5 For subsequent work

Four directions carry the analysis forward: a group or master-trust chassis in which the capital sits against a diversified book; design variants that shorten the run-off the office holds — fund-linked payouts or commutation options at vesting; an internal-model quantification replacing the standard-formula gate; and the Irish-data parallel calibration of Annex A promoted from benchmark to pricing basis as the domestic data matures.

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§10. Legal and regulatory framework

10.1 Solvency II

Authorisation, technical provisions and capital follow the framework stated in §6.1: Directive 2009/138/EC as transposed by S.I. No. 485 of 2015, Delegated Regulation (EU) 2015/35 for the best estimate, risk margin (Directive Article 77(5); Delegated Regulation Articles 37–39) and the standard-formula stresses (Articles 138, 140 and 142, Annex IV correlations), with classification as other life insurance under Article 55. Delegated Regulation (EU) 2026/269 amends the cost-of-capital rate from 30 January 2027 and is treated throughout as a quantified forward look; it does not amend Article 138.

10.2 Irish pensions law

The ARF regime arises under Part 30 of the Taxes Consolidation Act 1997 and the vested-PRSA regime under the PRSA provisions of the same Part; S.I. No. 485 of 2015 transposes the prudential framework; the Pensions Act 1990 and the IORP II transposition (S.I. No. 128 of 2021) govern the occupational periphery of the wrapper. The product is a policy of insurance held as an asset of the ARF or vested PRSA; it neither replaces the vehicle nor alters its ownership.

10.3 Revenue treatment and the imputed distribution

Both legs are scheme-internal: premiums pass from the pension vehicle to the insurer, and income returns to the vehicle, with the natural person taxed only through ordinary drawdown under the imputed-distribution regime (4% of fund value from age 61, 5% from 71, 6% above the €2m threshold; Revenue Pensions Manual, Chapters 23, 24 and 28). Two treatments require confirmation in practice before any writing decision: that intra-wrapper premium payments are

not themselves distributions, and the valuation treatment of the deferred policy within the fund for imputed-distribution purposes. The paper flags both as open regulatory questions rather than assuming answers.

10.4 Consumer protection and distribution

Distribution falls under the Insurance Distribution Directive as transposed (S.I. No. 229 of 2018) and, from 2026, the Consumer Protection Code 2025 (S.I. Nos. 80 and 81 of 2025); the product is within PRIIPs scope for disclosure. The forfeiture feature demands disclosure of term-assurance candour: the modal outcome is premiums paid and no benefit received, stated plainly, alongside the quantified value the pool returns to those who reach vesting (§7.3, F2). The commission analysis of §7.6 bears directly on the suitability and remuneration provisions of the 2025 Code.

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§11. Limitations, next steps and verification

11.1 Limitations

The analysis is single-life and level-premium on a central grid; joint-life, indexed-premium and group variants are unpriced. Every parameter is a choice, and the material ones carry quantified sensitivities in the workbook — the κ anchor (§3.2) moves the premium by 0.05% and no verdict; the documented lapse alternates move no verdict; the loadings are anchored where the Irish SFCR record is thin, and the expense base in particular is a market-convention figure. The stochastic benchmark inherits the limitations recorded in Annex A §A.7: a random-walk-with-drift κ process without regime switching or cohort terms, age extrapolation above the calibration range, and a cross-jurisdictional assumption tested by the Irish parallel calibration and its bootstrap. Capital is assessed on the standard formula only; an internal-model build is scoped, not performed. The Revenue confirmations of §10.3 are open. Nothing in the paper analyses demand.

11.2 Next steps

The four directions of §9.5, in the order a writing office would need them: the group chassis, the deferral-period reinsurance instrument, the internal-model quantification, and the Irish-base recalibration.

11.3 Reproducibility and verification

Every figure in this paper is a live formula in the companion workbook (v14.2.0: 45 sheets, 76,434 formulas), read by registered name from a fifty-name figure register; the workbook recalculates with zero errors and ships fifteen classified proofs and a tie system whose three documented non-zero residuals are stated on the file (the largest, €5.28 — 0.014% — reconciles the single-cell proving block to the annual engine). Annex B is generated from the workbook and ties to it cell for cell across all 1,326 numeric table entries. Annex A's calibration is verified at every layer: the fitted parameters are identical in the annex tables, the workbook's stochastic pack and the production projection; the raw-data pipeline regenerates the published 50,000-trajectory outputs bit-for-bit from fixed seeds; and a deterministic reconstruction reproduces the stress shifts the paper depends on — the operative shift ratio to within 0.005 at the entry age, the divergence growing to 0.106 at age 85 as the extrapolated region dominates, an estimator effect of the median-of-distribution convention rather than a discrepancy. The source layers are verified against the publications themselves: the CSO transcription matches the amended ILT17 edition exactly, and the EIOPA transcription matches all 150 published euro spot rates to zero. The workbook and annexes were additionally subjected to an independent computational audit — full recalculation, independent re-implementation of every production chain, and source verification — whose corrections are incorporated at workbook v14 and recorded in the accompanying erratum. Annex D is a reader's guide to the workbook for human and machine audit.

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§12. Conclusion

The question the paper set out to answer was whether a mutualised, forfeitable, regular-premium deferred annuity — the natural instrument for the Irish retiree's uninsured tail — can be written under current-rules Solvency II at a price that is fair to the purchaser. The answer divides cleanly. The instrument is sound: it funds itself, its pool balances to the cent, its mutualisation delivers a 24.2% subsidy to survivors, and it pays income in extreme old age that no unsecured strategy can match. It is fair to buy, on a distribution structure sized to the contract, with the repair costed at €253 of capital per policy. And it cannot be written: holding solvency coverage through a fifteen-year deferral requires €36,780 of day-one own funds per policy against €3,913 of lifetime margin, a ratio no tested lever brings within an order of viability, because the levers that improve fairness raise the requirement and the levers that lower the requirement breach fairness. The product is fair to buy and prohibitive to write, and the two facts have the same cause: a liability concentrated in survival past 80, held to a 99.5% standard through a premium-paying deferral.

One finding outlives the product decision. Measured on the liability it exists to capitalise, the standard formula's longevity stress delivers 0.545 of a stochastic 99.5% charge — a 20% flat decrement doing the work of the 33% age-

weighted decrement the benchmark implies — in every cell of a twenty-seven-cell surface. Whoever next brings deferred longevity to this market, on whatever chassis, will meet that calibration before they meet a customer.

Annex register

Annex A — Stochastic Mortality Projection Pack. The Cairns–Blake–Dowd calibration behind §6.3: data, parameters, fan charts, the Article 138 percentile placement on two national bases, and the raw-simulation pack that regenerates it. **Annex B — Full pricing and reserving surface.** The complete 16×16 premium surfaces, the commission panel, the 27-cell reserving and capital panels, and the six worked cells — generated from the workbook and tying to it cell for cell. **Annex C — Primary sources.** Every source relied on, with the specific editions and extracts identified. **Annex D — Workbook Guide.** Navigation, conventions, column guides and verification protocol for the companion workbook, for human and AI readers. **Companion workbook.** `MWP-2026-04_Audit_Workbook_v14.2.0.xlsx`, published with this paper.

About the author

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About Mylife.ie Research

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Remuneration disclosure

The author is the owner of SMP Financial Ltd, whose commercial activities include the sale of life-assurance and pension products to Irish consumers through the Mylife.ie trading channel. This paper is research output, not an advertisement for a product from any insurer. SMP Financial Ltd has no commercial arrangement with any manufacturer to develop or distribute the product described, and the author has no consulting, advisory or remuneration relationship with any insurer, reinsurer or intermediary named in this paper. If, in future, an insurer authorises a product of this specification and Mylife.ie or SMP Financial Ltd advises on its distribution, that arrangement will be disclosed at the point of any specific consumer advice, as the Consumer Protection Code 2025 requires.

Use of AI

This paper was drafted with the assistance of an AI research-and-writing tool acting under the direct supervision of the author. The tool was used to compile and synthesise the primary-source evidence, to construct the pricing, reserving and stochastic-mortality calculations documented in §§3–7 and Annex A, and to draft the prose under the author's direction and review. All numerical results are reproduced in the companion workbook, `MWP-2026-04_Audit_Workbook_v14.2.0.xlsx`, which contains no computed value that is not a live formula: there is no separate reproduction code to publish, because the model is the workbook. Its mortality basis is derived from the CSO's published table upward and its discount curve is taken from the EIOPA publication, both under live verification ties, and it carries fifteen classified proofs, each labelled substantive, identity or sensitivity so that no check reads as stronger than it is. The workbook and annexes were additionally subjected to an independent computational audit; its corrections are incorporated at workbook v14 and recorded in the accompanying erratum. All source citations were verified at the URLs given in Annex C. The author retains full editorial and professional responsibility for the paper's content, conclusions, and any errors of fact, interpretation or judgement.

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MWP-2026-04 — Annex A

Stochastic Mortality Projection Pack

Standalone edition · Extracted from Working Paper MWP-2026-04 v1.1.1

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Standard. Actuarial-level. Primary sources only. European conventions (day-month-year, € prefix where applicable).

Single-source numerical discipline. All life-expectancy figures in this annex are stochastic medians or empirical percentiles drawn from the same 50,000-trajectory CBD simulation. Article 138 stressed LE is a deterministic-q × (1 − 0.20) construction, by regulation. Where the two interact, Δ is always defined as `stressed_LE − stochastic_median`.

Relationship to the parent paper. This standalone edition contains the full Annex A body (§A.0 through §A.8) exactly as it appears in the finished MWP-2026-04 v1.1.1 paper. Cross-references in the text to §§3, 5, 6, 6.3, 6.4 refer to sections of the parent paper. The parent-paper Erratum register (Entries 1 through 10) governs both the parent paper and this standalone edition.

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Not personal financial advice. This annex is research output. It is not a recommendation and does not constitute personal financial advice.

A.0 Purpose of Annex A within the paper

The paper prices a single product — the regular-premium deferred lifetime income policy defined in §2 — using a deterministic mortality stack: ILT17 (CSO Irish Life Table) × IILMI A/E ratios (Society of Actuaries in Ireland, 2019) [^5] × CMI_2022 cohort projection (Continuous Mortality Investigation, Working Paper 177, 2023) [^6]. That stack supplies the central best-estimate mortality trajectory for pricing in §§3–5 and underpins the deterministic reserving calibration in §6.

What the deterministic stack does not supply is a quantified uncertainty distribution around longevity trend. The paper requires that distribution for one purpose:

1. **§6.3 — Article 138 sense-check.** The Solvency II longevity sub-module imposes a 20% instantaneous permanent decrease in mortality rates (Commission Delegated Regulation (EU) 2015/35, Article 138) [^4]. Is that calibration consistent with a 99.5% one-year value-at-risk on the trend process implied by a stochastic mortality model fitted to recent European data? Delegated Regulation (EU) 2026/269 reforms (effective 30 January 2027) do not amend Article 138; the 20% decrement stands.

A fan-chart at ages 65, 75 and 85 around the central projection illustrates the longevity-trend distribution used to answer that question.

Annex A delivers a single fitted stochastic mortality model — the Cairns–Blake–Dowd (CBD) two-factor model (Cairns, Blake and Dowd, 2006) [^1] — fitted to England & Wales (E&W) mortality data with a parallel calibration on Republic of Ireland data, both from the Human Mortality Database [^2]. It reports parameter estimates, projection trajectories, fan-charts at the three ages of interest, and explicit comparison to the 20% Article 138 mortality decrement.

A.1 Model selection rationale

Three families of stochastic mortality models were screened at Phase A:

Family	Reference	Form	Why considered
Lee–Carter	Lee and Carter (1992) [^7]	One-factor: ln m_{x,t} = a_x + b_x κ_t + ε	Most-cited stochastic mortality model; benchmark in the literature
Cairns–Blake–Dowd (CBD)	Cairns, Blake and Dowd (2006) [^1]	Two-factor on logit q_{x,t} with κ₁ (level) and κ₂ (age-slope)	Designed specifically for post-age-60 mortality
Renshaw–Haberman (cohort-	Renshaw and Haberman	LC + cohort term γ_{t−x}	Captures cohort effects

extended LC)	(2006) [^8]	LC + cohort term γ_{t-x}	Captures cohort effects

Selection. CBD is adopted as the base model for the following reasons:

- The relevant decision boundary is mortality at retirement ages and above (65 → maximum age). CBD is calibrated and validated on ages 60+. Lee–Carter calibrated on all ages tends to under-fit the post-65 cone.
- CBD's two-factor structure separates level of mortality (κ_1) from age-slope (κ_2). For the Article 138 sense-check the level shock at each age and the implied tail are decomposable.
- CBD is the model used in the longevity-trend literature for retirement-age mortality assessment, including the Cairns et al. (2009) [^3] eight-model comparison study, where it ranked among the better-performing models on E&W data.
- Renshaw–Haberman is referenced as a robustness consideration in §A.5 but is not run as the central model. Cohort effects in Irish/E&W data are modest at retirement ages relative to the level-and-slope decomposition.

The paper carries **two parallel calibrations** — CBD on England & Wales HMD and CBD on Republic of Ireland HMD — with headline numbers reported on both. The E&W fit is the methodologically cleaner comparator to CMI_2022 (which itself calibrates to E&W) and supplies the primary §6.3 Article 138 sense-check. The Irish fit is the jurisdictionally honest counterpart for the Irish pricing base.

A.2 Data

A.2.1 England & Wales (primary)

Source. Human Mortality Database (HMD), Max Planck Institute for Demographic Research, University of California Berkeley, and INED. Country: England & Wales (total population). URL: https://www.mortality.org/ [^2]. Series: 1×1 death rates by single age and single calendar year. Last modified per file header: 31 January 2025. Data confirmed on disk: 19 June 2026.

Age range. 60–89 inclusive (30 ages). CBD is specified on ages 60+; the upper boundary of 89 is applied because data quality thins materially above that age and the model assumption of logit-linearity in age weakens at the very-old tail.

Calendar window. 1991–2022 inclusive (32 years in raw data; 1991–2019, 29 years, used for drift calibration; 28 first-differences). 1991 is the start of the clean UK mortality improvement series. Pandemic years 2020–2021 are excluded from the κ-process drift calibration but are retained in raw data and fitted diagnostically.

Scale. Total deaths (both sexes combined) across ages 60–89, 1991–2022: 12,316,569. Mean annual deaths in the calibration window 1991–2019: approximately 383,298.

q_{x,t} range. At age 65, q spans 0.00975–0.01946 over the window. At age 89, 0.13627–0.18222.

A.2.2 Republic of Ireland (parallel)

Source. Human Mortality Database, country: Republic of Ireland. URL: https://www.mortality.org/ [^2]. Last modified per file header: 23 January 2025. Data confirmed on disk: 19 June 2026.

Age range. 60–89 inclusive, matching E&W.

Calendar window. 1991–2022 (same coverage confirmed at runtime). Drift calibration: 1991–2019 (28 first-differences).

Scale. Total deaths across ages 60–89, 1991–2022: 713,918 — approximately one-seventeenth of the E&W count. Mean annual deaths in the calibration window: approximately 22,109. This difference in sample size materially affects the precision of year-by-year κ estimates and thereby the estimated innovation covariance Σ; this is addressed quantitatively in §A.4b.3 via a parametric bootstrap.

q_{x,t} range. At age 65, 0.00795–0.02075. At age 89, 0.13680–0.22554.

A.2.3 Article 138 stress reference

Source. Commission Delegated Regulation (EU) 2015/35, Article 138, "Longevity risk sub-module": the capital requirement for longevity risk shall be equal to the loss in basic own funds that would result from an instantaneous permanent decrease of 20% in the mortality rates used for the calculation of technical provisions [^4].

Form used. Apply (1 – 0.20) × q_{x,t} to the central (median-κ deterministic) projection q-matrix for all ages and all future years, hold, and compute the resulting cohort LE at ages 65, 75, 85. Compare the resulting stressed LE to the empirical CBD LE distribution.

A.2.4 CMI_2022 reference

CMI_2022 (Continuous Mortality Investigation Working Paper 177, June 2023) [^6] is the model release accompanying

the CMI Mortality Projections Model CMI_2022. It is a paid, closed-access model. **CMI_2022 values are not reproduced in this annex.** The comparison table uses the CBD stochastic median as the central reference where CMI_2022 would normally appear; the CMI_2022 column is left unpopulated. See §A.7, Deviation-3.

A.3 Model specification and results

A.3.1 CBD functional form

For ages x ∈ {60, 61, ..., 89} and calendar years t ∈ {1991, ..., 2022}:

```
logit(q_{x,t}) = κ₁(t) + κ₂(t) · (x − 74.5)
```

where:

- q_{x,t} is the central mortality rate (deaths / central exposure-to-risk)
- logit(p) = ln(p / (1 – p))
- $\kappa_1(t)$ is the level factor — overall mortality level in year t
- $\kappa_2(t)$ is the slope factor — how mortality rises with age in year t
- $\bar{x}$ = 74.5 (midpoint of ages 60–89)

A.3.2 Parameter estimation

Method: weighted least squares (WLS) for each calendar year t separately, regressing logit(q_{x,t}) on (x – 74.5) with weights equal to deaths_{x,t}. Weights are clipped at a minimum of 0.1 to prevent division issues at sparse cells. This follows the original Cairns–Blake–Dowd (2006) [^1] procedure.

Calibration results (fitted κ series for 1991–2019):

E&W κ range (calibration window 1991–2019):

- κ_1: −3.6283 to −3.0178 (trend: declining, consistent with improving mortality)
- κ_2: 0.0992 to 0.1169 (trend: slightly rising, steepening age gradient)

Ireland κ range (calibration window 1991–2019):

- κ_1: −3.6605 to −2.8882
- κ_2: 0.1030 to 0.1202

Fitted κ series charts are shown in Figures A.1a (E&W) and A.1b (Ireland).



Figure A.1a. CBD fitted κ_1 (level, left axis) and κ_2 (slope, right axis), England & Wales, 1991–2022. Dashed lines: pandemic years 2020–2021, excluded from drift calibration.



Figure A.1b. CBD fitted κ_1 and κ_2, Republic of Ireland, 1991–2022. Greater year-to-year variability reflects smaller death counts (~22,000/year vs ~383,000/year for E&W).

A.3.3 κ-process drift estimation

The κ series are modelled as a bivariate random walk with drift:

```
(κ₁(t), κ₂(t))ᵀ = (κ₁(t−1), κ₂(t−1))ᵀ + μ + Σ^(1/2) · z_t
```

where $\mu = (\mu_1, \mu_2)^T$ is the drift vector, Σ is the 2×2 innovation covariance, and z_t ~ N(0, I).

Maximum-likelihood drift estimation on 28 first-differences (κ values for years 1991–2019; first-differences indexed 1992–2019):

Table A.1 — Drift parameters μ (MLE, 28 increments, calibration window 1991–2019)

Parameter	E&W	Standard error	Ireland	Standard error
μ_1 (level drift)	−0.021803	0.004041	−0.027577	0.004476
μ_2 (slope drift)	+0.000547	0.000233	+0.000546	0.000288

Negative μ_1 indicates ongoing mortality improvement (lower overall mortality level). Nearly identical μ_2 across bases indicates a stable age-slope trend.

Table A.2 — Innovation covariance Σ (MLE)

Element	E&W	Ireland	Ratio (IRE / E&W)
σ_{11} (var κ_1)	0.000457308	0.000561030	1.23×
σ_{22} (var κ_2)	0.000001516	0.000002324	1.53×

σ_{12} (cov)	0.0000185	0.00000909	—
ρ (correlation)	**0.7005**	**0.2521**	—

The substantially lower κ_1–κ_2 innovation correlation in Ireland ($\rho = 0.252$ vs $\rho = 0.701$ for E&W) is most likely an artefact of the noisier Irish κ estimates rather than a genuine structural difference in how level and slope co-move at retirement ages; the parametric bootstrap reported in §A.4b.3 supports this interpretation.

A.4 Build environment

Language. Python 3.11. Libraries: `numpy`, `scipy`, `statsmodels`, `pandas`, `matplotlib`, `reportlab`. All publicly available.

Reproducibility. Random seeds fixed at numpy.random.seed(20260618) for E&W and numpy.random.seed(20260619) for Ireland. Parametric bootstrap (§A.4b.3) uses numpy.random.default_rng(20260619). All inputs from public HMD download with date recorded in CSV headers. Scripts 01–08 are deterministic given fixed seeds and unchanged input files.

File layout:

```
data/
  qx_ew_1991_2022.csv
  qx_ire_1991_2022.csv
  deaths_ew_1991_2022.csv
  deaths_ire_1991_2022.csv
build/
  01_load_data.py
  02_fit_kappa.py
  03_kappa_drift.py
  04_project.py
  05_compare.py
  06_figures.py
  07_bootstrap_irish_sigma.py        (parametric bootstrap, §A.4b.3)
  08_rebuild_article138_table.py     (single-source consistent table rebuild)
outputs/
  params_ew.csv  params_ire.csv
  drift_ew.json  drift_ire.json
  le_ew.npz  le_ire.npz
  fan_ew_age65.png  ...  (6 fan-charts)
  kappa_series_ew.png  kappa_series_ire.png
  comparison_table_v2.md                (single-source consistent)
  article138_stress_v2.csv              (single-source consistent)
  article138_check_v2.json              (single-source consistent)
  bootstrap_irish_sigma.json            (§A.4b.3 result)
```

A.4b Parallel Irish calibration — jurisdictional gap

A.4b.1 Headline gap (median CBD cohort LE at 2022)

Table A.3 — Stochastic median cohort LE at starting year 2022, E&W vs Ireland

Starting age	E&W median	Ireland median	E&W minus Ireland
65	22.40	23.38	−0.98
75	13.61	14.10	−0.49
85	7.17	7.31	−0.14

The Irish calibration produces higher median cohort life expectancy at all three ages under the CBD model. At age 65 the gap is approximately one year. This is consistent with the Irish mortality improvement literature: Ireland entered its rapid mortality improvement phase later than England and Wales (principally from the mid-1990s onward) and the CBD model fitted to Irish HMD data therefore estimates a faster negative drift in κ_1 ($\mu_1 = -0.0276$ for Ireland vs -0.0218 for E&W), producing faster projected improvement and higher prospective LE from the same 2022 starting point.

The direction and approximate magnitude of the gap (approximately 1 year at age 65) is consistent with published Irish insured-lives mortality experience reported in the Society of Actuaries in Ireland Irish Insured Lives Mortality Investigation (Hall, Prendergast and Twomey, 2019) [^5], and with subsequent SAI demographic-committee analyses of base mortality. (Note: the IILMI 2019 study covers 2009–2015 insured-lives experience and is currently the most recent published Irish insured-lives investigation; it is flagged as STALE>24mo in the Phase A research dossier.)

A.4b.2 99.5%ile gap

Table A.4 — 99.5th percentile cohort LE at starting year 2022, E&W vs Ireland

Starting age	E&W 99.5%ile	Ireland 99.5%ile	E&W minus Ireland
65	24.83	25.98	−1.15
75	15.27	15.84	−0.57
85	8.11	8.29	−0.18

The 99.5%ile gap at age 65 (approximately 1.15 years) is marginally larger than the central gap (0.98 years). This is consistent with the wider Irish fan (see §A.4b.3). The Article 138 read-across verdict does **not** change sign between bases at any of the three ages (see §A.6).

A.4b.3 Fan-width decomposition (parametric bootstrap)

The 99.5%ile-minus-median CBD spread at age 65 is:

- E&W: 24.83 − 22.40 = **2.43 years**
- Ireland: 25.98 − 23.38 = **2.60 years**

The Irish spread is approximately 0.17 years wider. The ratio of estimated σ_{11} (level-innovation variance) is 1.23× (Ireland vs E&W), and the question is how much of that excess is genuine and how much is estimation noise arising from the smaller Irish death count (~22,000/year vs ~383,000/year).

To decompose this, a parametric bootstrap was run (`build/07_bootstrap_irish_sigma.py`, output `outputs/bootstrap_irish_sigma.json`, B = 1,000 draws, seed = 20260619). For each draw, a κ path of length 29 years (1991–2019) is simulated under the E&W fitted (μ, Σ) — the assumed-true signal. Death counts at each age and year are drawn from a Poisson distribution with mean equal to the Irish central exposure-to-risk multiplied by the implied q_{x,t}. The CBD κ series is then refit by WLS and the drift parameters re-estimated by MLE, exactly as in the headline calibration. The resulting distribution of $\hat{\sigma}_{11}$ characterises the noise an Irish-sized sample would introduce around a true E&W signal.

Table A.5 — Parametric bootstrap of σ_{11} at Irish sample size, under E&W signal

Quantity	Value	Units
σ_{11} (E&W fitted, taken as "truth")	4.573×10^{-4}	variance
σ_{11} (Irish observed)	5.610×10^{-4}	variance
σ_{11} (bootstrap mean, Irish scale)	5.413×10^{-4}	variance
σ_{11} (bootstrap median)	5.302×10^{-4}	variance
σ_{11} (bootstrap 95% CI)	$[2.930 \times 10^{-4}, 8.635 \times 10^{-4}]$	variance
Inflation factor at Irish scale	1.18×	dimensionless
Total observed Irish excess over E&W	1.04×10^{-4}	variance
of which: sampling-noise component	0.84×10^{-4} (81%)	variance (% of excess)
of which: residual (genuine + structural)	0.20×10^{-4} (19%)	variance (% of excess)

Interpretation. Approximately 81% of the observed Irish σ_{11} excess over E&W is attributable to estimation noise from the smaller Irish death count, under the assumption that the underlying Irish trend signal is the same as E&W. Approximately 19% is residual and could reflect genuine Irish-specific trend uncertainty, structural differences, or model mis-specification. The 95% bootstrap CI for $\hat{\sigma}_{11}$ ($[2.93 \times 10^{-4}, 8.64 \times 10^{-4}]$) easily contains the Irish observed value (5.61×10^{-4}), so the null hypothesis "Irish trend signal = E&W trend signal" is **not rejected** by the data at conventional confidence levels.

The Irish fan should therefore be interpreted as an upper bound on Irish-specific trend uncertainty rather than a calibrated point estimate of it. The paper body should carry this caveat when citing Irish CBD numbers, particularly when the 99.5%ile is being used as a regulatory comparator. The genuine-uncertainty component (~19% of the observed excess, ≈ 4% above E&W in absolute σ_{11} terms) is small relative to other model-choice uncertainties.

A.4b.4 Editorial recommendation

Primary §6.3 statement: use E&W calibration (cleaner comparator to CMI_2022; larger sample; established UK actuarial benchmark). **Supplementary:** report Irish calibration alongside, noting the 1-year median gap and the §A.4b.3 bootstrap result. Both bases reach the same verdict on Article 138 at age 65 (inadequate against the 99.5%ile benchmark) and the same verdict at older ages (adequate or exceeding the 99.5%ile benchmark — see §A.6).

A.5 Sensitivities — items not run in this build

The following sensitivities are within the scope of §A.5 but are not executed in the present build. They are flagged for a subsequent recalibration cycle.

1. **Calibration window 2001–2021 (20-year window).** Re-running WLS fit and drift estimation on this shorter window would give more weight to recent trend. Expected effect: μ_1 more negative (faster recent improvement),

wider σ_{11} (less data). Not run.

2. **Pandemic inclusion (1991–2021 with 2020–2021 included in drift calibration).** Expected effect: would increase estimated σ_{11} materially and shift μ_1 toward less negative (pandemic pushes κ_1 back up temporarily). Not run.
3. **Poisson-MLE estimator.** The WLS estimator (CBD 2006 original) is used as primary. The Poisson-MLE alternative (maximum likelihood with Poisson-deaths likelihood) would give similar point estimates but potentially different standard errors. Not run.
4. **Renshaw–Haberman cohort extension.** Adding a cohort term γ_{t–x} to the CBD model. Cohort effects in Irish/E&W data at retirement ages are modest; the central projection is not expected to shift materially. Not run.

(Note: the parametric bootstrap on Irish σ_{11} — listed as a fifth deferred item in earlier drafts — was executed in this build and is reported in §A.4b.3.)

All four remaining sensitivities are candidates for a subsequent recalibration cycle.

A.6 Deliverables tied to the paper

A.6.1 §6.3 Article 138 sense-check

The Solvency II Article 138 longevity stress of a 20% permanent decrease in mortality rates corresponds, in the CBD model fitted to E&W HMD 1991–2019, to a **97.9th percentile** event on the empirical CBD cohort-LE distribution at age 65. On the Ireland base, the corresponding percentile is the **97.3rd**.

Table A.6 — Article 138 percentile location in the CBD LE distribution, all bases and ages

Base	Age	Stochastic median LE	Article 138 stressed LE	Δ (years)	Art.138 percentile in CBD distribution	Verdict vs 99.5%
E&W	65	22.397	24.253	+1.856	97.9	inadequate
E&W	75	13.614	15.193	+1.579	99.3	marginal/adequate
E&W	85	7.175	8.330	+1.155	99.9	exceeds
Ireland	65	23.381	25.279	+1.898	97.3	inadequate
Ireland	75	14.102	15.723	+1.621	99.2	marginal
Ireland	85	7.312	8.488	+1.176	99.9	exceeds

The Article 138 verdict is age-dependent. At age 65 the 20% decrement falls materially short of the 99.5%ile benchmark on both calibration bases. At age 75 it sits approximately at the 99% percentile — marginal, not clearly inadequate. At age 85 it exceeds the 99.5%ile benchmark on both bases. This pattern reflects the fact that a multiplicative shock to q_{x,t} produces a larger absolute LE shift at younger starting ages, where more years of cumulative compounding occur.

Conclusion for §6.3 of the paper body. At the policyholder's entry age (65 in the paper's representative case), Article 138 corresponds to roughly the 98th percentile of the CBD trend-uncertainty distribution, not the 99.5th. A CBD-calibrated 99.5% stress at age 65 would require a further +0.58 years of life expectancy (E&W: 99.5%ile LE 24.83 − Art.138 stressed LE 24.25) or +0.70 years (Ireland: 25.98 − 25.28). The 20% decrement is therefore **inadequate** at retirement entry age relative to the 99.5% benchmark the model implies, becomes **marginally adequate** at later starting ages, and **exceeds** the benchmark at age 85. The paper's SCR_long calculation is dominated by post-vesting cashflows over the longevity tail; the largest sensitivity sits at the older ages where CBD's cohort-specific mortality-improvement uncertainty has had the longest horizon over which to compound. The inadequate verdict at the representative entry age of 65 is the operative one for the paper's capital-charge analysis at younger vesting ages, and the age-dependent pattern is what supports the panel-level verdict in §6.4.

This finding is consistent with the academic literature noting that the Article 138 calibration was set under pre-2010 data and the improvements in mortality projection models since then have widened the implied distribution (see Cairns et al., 2009 [^3]).

A.6.2 Fan-charts

Figures A.2–A.7 (below) show the cohort LE fan-charts for all six (base, starting age) combinations.



Figure A.2. CBD cohort LE fan-chart, England & Wales, starting age 65. Bands: 0.5–99.5%ile (lightest), 5–95%ile, 25–75%ile (darkest). Solid line: median. Dashed line: 99.5th percentile. 50,000 trajectories.



Figure A.3. CBD cohort LE fan-chart, England & Wales, starting age 75.



Figure A.4. CBD cohort LE fan-chart, England & Wales, starting age 85.



Figure A.5. CBD cohort LE fan-chart, Republic of Ireland, starting age 65.



Figure A.6. CBD cohort LE fan-chart, Republic of Ireland, starting age 75.



Figure A.7. CBD cohort LE fan-chart, Republic of Ireland, starting age 85.

A.6.3 Comparison table (single-source consistent)

The comparison table is reproduced from `outputs/comparison_table_v2.md`. All central LE values are the stochastic median of the 50,000-trajectory CBD simulation, consistent across percentiles, Article 138 deltas, and the headline JSON `outputs/article138_check_v2.json`.

CBD Life Expectancy Percentiles at Starting Age (Cohort commencing 2022)

Age	E&W Median	E&W 25/75	E&W 5/95	E&W 0.5/99.5	IRL Median	IRL 25/75	IRL 5/95	IRL 0.5/99.5	Gap (EW−IRL)
65	22.40	21.85 / 22.97	21.12 / 23.85	20.48 / 24.83	23.38	22.79 / 24.01	22.01 / 24.97	21.32 / 25.98	−0.98
75	13.61	13.24 / 14.01	12.75 / 14.61	12.31 / 15.27	14.10	13.71 / 14.52	13.19 / 15.16	12.71 / 15.84	−0.49
85	7.17	6.96 / 7.40	6.68 / 7.75	6.42 / 8.11	7.31	7.09 / 7.54	6.80 / 7.91	6.54 / 8.29	−0.14

Article 138 Stress (20% permanent decrease in q_{x,t})

Central LE values below are the stochastic median (consistent with the percentile table above). Δ = stressed LE − stochastic median.

Base	Age	Central LE (stoch. median)	Stressed LE (Art.138)	Δ (years)	Art.138 percentile in CBD distribution
E&W	65	22.397	24.253	+1.856	97.9
E&W	75	13.614	15.193	+1.579	99.3
E&W	85	7.175	8.330	+1.155	99.9
Ireland	65	23.381	25.279	+1.898	97.3
Ireland	75	14.102	15.723	+1.621	99.2
Ireland	85	7.312	8.488	+1.176	99.9

CMI_2022 deterministic central reference: not available (closed-access model); CMI_2022 column is left unpopulated. See §A.7, Deviation-3.

A.7 Limitations and deviations from specification

Limitation 1 — Cross-jurisdictional assumption. The E&W and Ireland CBD calibrations are derived from different populations. The CMI_2022 model (which this annex benchmarks against) is itself calibrated to E&W data [^6]. Application of CBD results to Irish pricing carries the assumption that Irish trend dynamics are adequately captured. The parallel Irish calibration directly tests this; the headline gap is approximately 1 year at age 65 (Ireland higher), and the parametric bootstrap in §A.4b.3 indicates the Irish-specific signal is not distinguishable from the E&W signal at conventional confidence levels.

Limitation 2 — Random-walk-with-drift assumption. Long-horizon projections (40+ years) extrapolate a 28-year fitted drift. The fan-chart cone widens proportionally. Structural breaks (post-2011 UK improvement slowdown, post-pandemic regime shift) are not modelled with regime-switching. The pandemic-exclusion calibration (drift from 1991–2019) is the working compromise.

Limitation 3 — No cohort effect. Cohort effects are omitted from the base case. The Renshaw–Haberman sensitivity (§A.5 item 4) tests robustness; it is not run in the present build.

Limitation 4 — Age extrapolation 90–110. Ages 90–110 are outside the calibration range (60–89). The linear logit model $\text{logit}\ q_{x,t} = \kappa_1(t) + \kappa_2(t)\cdot(x - 74.5)$ is applied by extrapolation. This is standard practice in the CBD literature but will over-estimate or under-estimate mortality at the oldest ages depending on the κ_2 trajectory. See Deviation-2 below.

Materiality of the terminal age. The projection is closed at age 110. That closure is immaterial to the reported life expectancies: cohort survival to age 110 is 0.000286 at starting age 65, 0.000194 at 75 and 0.000187 at 85, so the truncated tail contributes under one thousandth of a year. Life expectancy computed at closures of 110, 115 and 120 is identical to three decimal places. Limitation 4 therefore bears on the shape of mortality within the 90–110 range, not on where the range ends.

Internal consistency of the innovation parameters. The declared innovation covariance $\sigma_{12} = 1.85 \times 10^{-5}$ agrees with the product of the reported correlation and standard deviations, $\rho\cdot\sigma_1\cdot\sigma_2 = 1.8444 \times 10^{-5}$, to 5.6×10^{-8}. The correlation and the covariance therefore describe the same fitted process, as they must.

Deviation-1 — Projection start (documented). Spec §A.3.4 discusses two options for the 2022 starting point. This build uses: start from κ_2019 (last calibrated, pandemic-excluded) and apply three deterministic mean-drift steps to reach 2022, then begin the stochastic simulation. This is the "actuarially cleaner option" per the spec's own wording.

Deviation-2 — Age extrapolation 90–110 (documented). As described in Limitation 4 above.

Deviation-3 — CMI_2022 not reproduced. CMI_2022 (Working Paper 177, June 2023) [^6] is a closed-access paid model. The CMI_2022 column in the comparison table is left unpopulated; the CBD stochastic median serves as the central reference in its place.

Deviation-4 — Horizon interpretation (documented). The specification requests LE at "horizons 10/20/30 years." The projection script computes LE distributions for cohorts beginning in 2022 only. The comparison table reports LE for cohorts of ages 65, 75, 85 beginning in 2022, which implicitly captures horizons of roughly 20–45 years. Re-running full Monte-Carlo simulations for cohorts beginning in 2032, 2042 and 2052 is not run in the present build.

Deviation-5 — Fan-chart x-axis approximation (documented). Fan-charts show LE across projection starting years 2022–2080 by applying κ percentile paths (stored as percentile summaries from the 50,000-trajectory simulation) to deterministic forward LE from each starting year. This gives the correct shape of trend uncertainty across the fan; the 2022 starting-year slice is exact from the full MC simulation.

Note on the life-expectancy estimator. The life expectancies reported in this annex are medians of the life-expectancy distribution across the 50,000 simulated trajectories, as Deviation-5 records. They are therefore not equal to the life expectancy of the median κ trajectory, which a deterministic drift-only reconstruction produces. The two differ by a Jensen effect: survival compounds multiplicatively over the projection horizon, so the mapping from κ to life expectancy is convex, and the simulated fan is wide — the κ_1 standard deviation reaches 0.14 at forty-five years, comparable to the 0.223 logit shift that Article 138 imposes.

An independent deterministic reconstruction from the parameters in §A.3 gives 21.592, 13.032 and 6.857 years at starting ages 65, 75 and 85, against the simulated medians of 22.397, 13.614 and 7.175 reported in §A.4b.1 — lower by 3.6%, 4.3% and 4.4% respectively, the gap widening with age as the extrapolated region above age 89 takes a larger share of remaining life. This is an estimator difference and not a discrepancy: the two figures answer different questions, and no reconciliation between them is required.

The stress *shifts* on which §6.3 and §6.4 of the parent paper depend are differences of like-for-like quantities, so the estimator bias cancels. A deterministic reconstruction reproduces the Article 138 shift at age 65 as 1.882 years against 1.856 here, and the 99.5% shift as 2.453 against 2.433. The ratio of the two, which is the operative figure, reproduces to within 0.004. Four candidate defects were tested and eliminated before the estimator explanation was reached: drift rounding, the Deviation-1 projection start, the terminal-age closure, and internal parameter inconsistency.

A.8 Sources

References cited throughout §A.0–§A.7 appear as numbered footnotes at the end of this document. Full bibliographic detail, DOIs, and URLs are given in each footnote entry.

[^1]: Cairns, A.J.G., Blake, D. and Dowd, K. (2006). "A Two-Factor Model for Stochastic Mortality with Parameter Uncertainty: Theory and Calibration." *Journal of Risk and Insurance*, 73(4), pp. 687–718. https://doi.org/10.1111/j.1539-6975.2006.00195.x

[^2]: Human Mortality Database. Max Planck Institute for Demographic Research, University of California, Berkeley, and INED. Available at: https://www.mortality.org/. England & Wales data last modified 31 January 2025; Ireland data last modified 23 January 2025. Accessed 19 June 2026.

[^3]: Cairns, A.J.G., Blake, D., Dowd, K., Coughlan, G.D., Epstein, D., Ong, A. and Balevich, I. (2009). "A Quantitative Comparison of Stochastic Mortality Models Using Data from England and Wales and the United States." *North American Actuarial Journal*, 13(1), pp. 1–35. https://doi.org/10.1080/10920277.2009.10597538

[^4]: Commission Delegated Regulation (EU) 2015/35 of 10 October 2014 supplementing Directive 2009/138/EC (Solvency II). Article 138, Longevity risk sub-module. Official Journal of the European Union, L 12, 17 January 2015. https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32015R0035

[^5]: Hall, M., Prendergast, S. and Twomey, C. (2019). *Irish Insured Lives Mortality Investigation (IILMI), 2009–2015*. Technical Report. Society of Actuaries in Ireland, Demography Committee. https://doras.dcu.ie/31220/

[^6]: Continuous Mortality Investigation (2023). *CMI Mortality Projections Model: CMI_2022*. Working Paper 177, June 2023. Institute and Faculty of Actuaries. https://www.actuaries.org.uk/learn-and-develop/continuous-mortality-investigation/cmi-working-papers/mortality-projections/cmi-working-paper-177

[^7]: Lee, R.D. and Carter, L.R. (1992). "Modeling and Forecasting U.S. Mortality." *Journal of the American Statistical Association*, 87(419), pp. 659–671. https://www.jstor.org/stable/2290201

[^8]: Renshaw, A.E. and Haberman, S. (2006). "A Cohort-Based Extension to the Lee–Carter Model for Mortality Reduction Factors." *Insurance: Mathematics and Economics*, 38(3), pp. 556–570. https://doi.org/10.1016/j.insmatheco.2005.12.001

Colophon

Standalone edition, version 2.0.0, July 2026. MWP-2026-04 — Annex A, Stochastic Mortality Projection Pack. Supersedes the edition extracted from MWP-2026-04 v1.1.1 on 16 July 2026. Three passages are added relative to that edition: an internal-consistency check on the innovation parameters at §A.3.3, a materiality statement on the terminal age appended to Limitation 4, and a note on the life-expectancy estimator following Deviation-5. No figure in this annex changes. The Annex A body otherwise remains as it ships in the parent paper.

Supersedes. Annex A standalone editions v0.1 (18 June 2026), v0.2 (19 June 2026), and v0.3 PDF render (20 June 2026).

Parent-paper components (companion reading).

- MWP-2026-04 v2.0.0 Master (markdown) — the finished paper, rebuilt from the workbook.
- MWP-2026-04 Audit Workbook v10.0.0 (`.xlsx`) — the auditable pricing, reserving and capital workbook underpinning the paper and Annex B. It contains no computed value that is not a live formula. The Cairns–Blake–Dowd calibration in this annex is rebuilt there on sheet `CBD_Stochastic` from the parameters given in §A.3.
- MWP-2026-04 v1.1.2 Reader's Guide — the consumer-facing companion to the finished paper.
- MWP-2026-04 Erratum register (Entries 1 through 11) — governs both the parent paper and this standalone edition.

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End of Annex A standalone edition.

Annex B — Full pricing and reserving surface

Version 2.1.0, July 2026. Supersedes v2.0.0 and the edition shipped with MWP-2026-04 v1.1.1.

Generated from the companion workbook, `MWP-2026-04_Audit_Workbook_v14.2.0.xlsx`. Every figure below is a live cell in that file. This annex is generated rather than transcribed, so a change of basis cannot leave it behind. The prior edition was transcribed from CSV extracts and its figures were on the superseded funding base.

What has changed since v1.1.1

At v2.1.0 (this issue). The §B.6 binding-duration sentence is corrected — the binding-to-deferral ratio runs from 0.29 to 0.85 and rises with deferral; the corner note names the correct cells (74/76 and 75/77 exceed €10,000 a month; the 75/76 cell is infeasible); an infeasible-corner note is added above Table B.1; and the companion citation is updated to workbook v14.2.0. Table values are unchanged and continue to tie to the workbook cell for cell. The entries below date from v2.0.0.

Four things, and they should be read before the tables.

The funding base is corrected. The prior edition priced on a basis that credited lapsing members' premiums twice — once through the persisting-premium leg and again through a separate forfeiture credit. Premiums are now counted once, on the date they are paid. This raises the premium by about 8%.

The lapse curve is the documented one — year 1 5.8%, year 2 3.1%, years 3–5 1.9%, year 6 onward 1.3% — replacing an engine curve that added a uniform 25 basis points at every duration.

The adequacy ratio is computed on a different basis, and this moves every verdict. The prior edition derived the ratio from a life-expectancy-weighted stress. It is now computed by applying the stochastic stress directly to the liability. Life expectancy weights ages where the stress is mild; the liability weights ages 80 and above where it is severe. Section 6.3 of the parent paper sets this out. **Every cell now reads inadequate**, against thirteen of twenty-seven previously.

A new table, B.6, gives the capital requirement per cell. The prior edition carried the longevity charge and the adequacy verdict but no capital requirement. B.6 closes the scope limitation the parent paper recorded at §11.1.

Conventions

Income is stated as **€1,000 per month commencing at the vesting date**, escalating with prices thereafter, as in the

prior edition. Note that sections 4 and 5 of the parent paper state income in inception-dated terms; the two differ by 1.3459 at a fifteen-year deferral. Because administration expense is a fixed amount per policy rather than a share of the benefit, **premiums are not proportional to the income secured** and these tables cannot be rescaled to another income level by simple proportion.

Reading the corners. The surface includes short-deferral combinations where a heaped commission absorbs a large share of a very short premium base. The commission factor reaches 17.2% at a ten-year deferral against 11.1% at thirty years, and the premiums at entry 74 vesting 76 (€14,267.72) and entry 75 vesting 77 (€13,506.38) exceed ten thousand euro a month, while the entry 75 / vesting 76 cell itself is infeasible. Those cells are included for completeness of the arithmetic surface. They are outside the commercially plausible band the six worked examples span, and the caveat from the prior edition stands.

B.1 Monthly premium surface — heaped and trail

Monthly premium (€) to secure €1,000 per month from the vesting date. Entry ages 60–75 down, vesting ages 75–90 across. Blank cells are infeasible. Two corner cells (entry 74 / vesting 75 and entry 75 / vesting 76) display large negative values: below a two-year premium term the pricing identity has no solution — the boundary is commission factor = 1 − margin — and the raw roots are shown only so that every cell ties to the workbook; read them as blank.

Entry \ Vest	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
60	794.89	688.51	597.53	519.10	451.06	391.74	339.84	294.36	254.43	219.35	188.53	161.47	137.78	117.09	99.11	83.57
61	871.99	750.95	648.48	560.95	485.59	420.32	363.53	313.98	270.66	232.75	199.54	170.48	145.10	123.01	103.85	87.33
62	962.59	823.80	707.28	608.75	524.71	452.46	390.01	335.81	288.64	247.52	211.65	180.35	153.11	129.46	109.01	91.41
63	1,070.58	909.46	775.93	663.97	569.41	488.88	419.79	360.22	308.66	263.91	225.02	191.23	161.90	136.53	114.65	95.87
64	1,201.35	1,011.60	856.70	728.48	621.09	530.54	453.57	387.70	331.06	282.16	239.86	203.25	171.60	144.30	120.83	100.74
65	1,362.09	1,135.35	953.06	804.42	681.52	578.75	492.24	418.90	356.30	302.61	256.41	216.60	182.33	152.87	127.63	106.10
66	1,564.75	1,287.50	1,069.86	895.06	752.68	635.14	537.02	454.65	384.98	325.67	274.97	231.50	194.26	162.37	135.15	112.00
67	1,826.94	1,479.41	1,213.52	1,004.99	837.69	701.62	589.46	496.08	417.88	351.91	295.93	248.24	207.60	172.96	143.50	118.54
68	2,178.38	1,727.80	1,394.82	1,140.28	940.86	781.09	651.33	544.67	456.06	382.04	319.80	267.17	222.60	184.81	152.81	125.81
69	2,672.47	2,060.87	1,629.60	1,311.13	1,067.92	877.62	725.37	602.06	500.90	417.07	347.27	288.78	239.60	198.17	163.27	133.94
70	3,415.80	2,529.35	1,944.59	1,532.52	1,228.51	996.60	815.41	670.81	553.92	458.27	379.25	313.67	259.03	213.33	175.08	143.10
71	4,682.14	3,234.17	2,387.69	1,829.61	1,436.66	1,147.06	926.44	754.47	617.50	507.05	416.92	342.72	281.47	230.71	188.52	153.46
72	7,236.70	4,435.16	3,054.59	2,247.75	1,716.17	1,342.22	1,066.97	857.76	694.98	565.63	461.60	376.99	307.70	250.81	203.95	165.27
73	15,046.25	6,858.37	4,191.33	2,877.39	2,109.80	1,604.49	1,249.42	988.63	790.75	637.12	515.34	417.71	338.74	274.38	221.86	178.89
74	-435,966.72	14,267.72	6,485.86	3,951.14	2,702.92	1,974.13	1,494.83	1,158.73	912.26	725.60	581.04	466.80	375.69	302.34	242.91	194.75
75	—	-413,238.47	13,506.38	6,119.96	3,715.09	2,531.57	1,841.04	1,387.80	1,070.41	838.06	662.51	526.94	420.34	335.72	267.97	213.46

Table B.1. Source: workbook sheet `Surface_Engine`*, rows 236–251.*

B.2 Equivalence-only surface

The same surface at pure equivalence — no commission, no provider margin and no expense loading. The difference from B.1 is the total loading.

Entry \ Vest	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
60	646.93	561.58	488.01	424.14	368.41	319.56	276.64	238.86	205.57	176.23	150.39	127.63	107.67	90.20	74.99	61.82
61	706.79	610.52	528.27	457.46	396.08	342.60	295.82	254.83	218.84	187.23	159.46	135.08	113.75	95.13	78.96	64.99
62	776.32	667.05	574.33	495.21	427.19	368.32	317.14	272.49	233.46	199.29	169.39	143.21	120.37	100.49	83.26	68.41
63	858.06	732.74	627.57	538.43	462.47	397.27	340.95	292.12	249.63	212.60	180.29	152.12	127.60	106.32	87.93	72.12
64	955.46	810.00	689.46	588.41	502.88	430.11	367.77	314.07	267.63	227.33	192.33	161.91	135.52	112.70	93.03	76.16
65	1,072.86	902.11	762.29	646.55	549.65	467.77	398.22	338.81	287.76	243.74	205.67	172.72	144.25	119.70	98.61	80.57
66	1,217.42	1,013.18	849.18	715.02	604.10	511.39	433.17	366.93	310.48	262.11	220.54	184.72	153.90	127.42	104.74	85.41
67	1,398.91	1,149.99	953.97	796.72	668.25	562.19	473.69	399.23	336.32	282.86	237.21	198.11	164.62	135.97	111.51	90.73
68	1,632.94	1,321.81	1,083.11	895.33	744.86	622.10	520.92	436.71	366.04	306.49	256.05	213.14	176.59	145.47	119.02	96.61
69	1,945.27	1,543.44	1,245.38	1,016.91	837.37	693.69	576.66	480.46	400.58	333.71	277.55	230.16	190.06	156.11	127.38	103.15
70	2,381.83	1,839.35	1,454.80	1,169.78	951.52	780.21	643.34	532.14	440.93	365.39	302.36	249.60	205.33	168.09	136.76	110.45
71	3,049.23	2,253.15	1,734.55	1,367.18	1,095.14	887.07	724.00	594.04	488.66	402.45	331.27	272.08	222.82	181.71	147.35	118.66
72	4,157.66	2,885.72	2,125.79	1,630.93	1,280.67	1,021.58	823.68	668.95	545.89	446.35	365.14	298.33	243.07	197.34	159.41	127.94
73	6,353.83	3,936.55	2,724.06	1,999.98	1,528.71	1,195.46	949.25	761.64	615.23	499.04	405.32	329.13	266.77	215.48	173.29	138.55
74	12,977.41	6,019.04	3,718.28	2,564.55	1,875.96	1,428.08	1,111.72	878.52	701.12	562.97	453.64	365.73	294.64	236.76	189.44	150.78
75	—	12,300.67	5,689.38	3,503.26	2,407.51	1,754.01	1,329.27	1,029.91	809.57	642.29	512.36	409.83	327.84	261.85	208.44	165.07

Table B.2. Source: `Surface_Engine`*, rows 256–271.*

B.2b Total loading

B.1 less B.2, in euro per month.

Entry \ Vest	75	76	77	78	79	80	81	82	83	84	85	86	87	88	89	90
60	147.96	126.93	109.53	94.96	82.65	72.17	63.21	55.50	48.86	43.12	38.15	33.84	30.11	26.89	24.12	21.75
61	165.19	140.43	120.21	103.49	89.51	77.73	67.71	59.16	51.82	45.52	40.08	35.40	31.35	27.88	24.89	22.34
62	186.27	156.75	132.95	113.54	97.52	84.14	72.87	63.32	55.19	48.23	42.27	37.14	32.75	28.98	25.75	23.00
63	212.51	176.72	148.37	125.54	106.95	91.61	78.83	68.10	59.02	51.31	44.73	39.11	34.31	30.21	26.71	23.75
64	245.89	201.59	167.24	140.07	118.21	100.43	85.80	73.63	63.43	54.82	47.53	41.34	36.07	31.60	27.80	24.58
65	289.23	233.24	190.77	157.87	131.87	110.98	94.02	80.09	68.53	58.87	50.74	43.88	38.07	33.17	29.02	25.53
66	347.33	274.31	220.68	180.04	148.58	123.76	103.85	87.72	74.50	63.56	54.43	46.78	40.36	34.95	30.41	26.59
67	428.02	329.43	259.54	208.26	169.44	139.43	115.78	96.85	81.55	69.04	58.72	50.14	42.98	36.99	31.99	27.81
68	545.44	405.99	311.71	244.95	196.00	158.99	130.42	107.96	90.02	75.55	63.75	54.03	46.00	39.34	33.80	29.20
69	727.20	517.43	384.22	294.22	230.55	183.93	148.71	121.60	100.32	83.36	69.71	58.62	49.54	42.06	35.89	30.79
70	1,033.97	690.00	489.79	362.74	276.99	216.39	172.06	138.67	112.99	92.88	76.90	64.07	53.70	45.24	38.32	32.64
71	1,632.91	981.02	653.14	462.43	341.52	259.99	202.44	160.44	128.84	104.59	85.65	70.64	58.65	48.99	41.16	34.80
72	3,079.03	1,549.44	928.80	616.82	435.50	320.64	243.29	188.80	149.10	119.28	96.45	78.66	64.63	53.47	44.53	37.33
73	8,692.42	2,921.82	1,467.27	877.41	581.09	409.04	300.17	227.00	175.52	138.08	110.01	88.59	71.96	58.90	48.57	40.34
74	-448,944.13	8,248.68	2,767.58	1,386.59	826.96	546.05	383.11	280.21	211.14	162.63	127.40	101.07	81.05	65.58	53.48	43.96
75	—	-425,539.14	7,817.00	2,616.70	1,307.58	777.56	511.77	357.90	260.83	195.77	150.15	117.11	92.50	73.87	59.53	48.38

Table B.2b. Source: `Surface_Engine`*, rows 276–291.*

B.3 Pricing panel — five commission structures

Seven representative entry ages against four vesting ages. **The commission factor is computed per cell rather than taken as a constant**, because a heaped payment is a larger share of a short premium base. The structures are: heaped and trail (100% of the first premium plus 5% thereafter, the default); zero, for execution-only or fee-based distribution; level 20% flat; industry reference (100% year 1, 20% years 2–4, 3% year 5 onward); and right-sized (100% year 1 plus 1%), derived in §7.6 of the parent paper.

Entry	Vest	Commission factor, heaped	Monthly premium, heaped (€)	Zero (€)	Level 20% (€)	Industry ref (€)		Equivalence only (€)
60	75	13.77%	**794.89**	682.08	859.25	818.17	**761.67**	*646.93*
60	80	12.34%	**391.74**	341.91	430.72	399.56	**375.37**	*319.56*
60	85	11.56%	**188.53**	166.06	209.20	191.38	**180.66**	*150.39*
60	90	11.13%	**83.57**	73.98	93.19	84.61	**80.08**	*61.82*
63	75	15.36%	**1,070.58**	901.08	1,135.12	1,113.54	**1,025.80**	*858.06*
63	80	13.20%	**488.88**	422.36	532.06	501.31	**468.45**	*397.27*
63	85	12.13%	**225.02**	196.87	248.01	229.20	**215.62**	*180.29*
63	90	11.57%	**95.87**	84.43	106.36	97.31	**91.87**	*72.12*
65	75	16.96%	**1,362.09**	1,123.95	1,415.89	1,432.45	**1,305.08**	*1,072.86*
65	80	13.97%	**578.75**	495.40	624.07	596.34	**554.55**	*467.77*
65	85	12.62%	**256.41**	223.06	281.00	261.93	**245.70**	*205.67*
65	90	11.93%	**106.10**	93.04	117.21	107.92	**101.67**	*80.57*
68	75	21.07%	**2,178.38**	1,705.27	2,148.19	2,363.11	**2,087.03**	*1,632.94*
68	80	15.61%	**781.09**	655.41	825.65	813.46	**748.41**	*622.10*
68	85	13.55%	**319.80**	275.14	346.61	328.54	**306.43**	*256.05*
68	90	12.60%	**125.81**	109.46	137.89	128.48	**120.55**	*96.61*
70	75	26.50%	**3,415.80**	2,482.68	3,127.54	3,888.68	**3,272.17**	*2,381.83*
70	80	17.24%	**996.60**	819.43	1,032.26	1,049.53	**954.89**	*780.21*
70	85	14.37%	**379.25**	323.06	406.97	391.62	**363.40**	*302.36*
70	90	13.16%	**143.10**	123.68	155.80	146.62	**137.12**	*110.45*
72	75	39.01%	**7,236.70**	4,326.36	5,450.09	8,677.75	**6,929.82**	*4,157.66*
72	80	19.68%	**1,342.22**	1,069.88	1,347.77	1,438.70	**1,285.98**	*1,021.58*
72	85	15.44%	**461.60**	388.10	488.91	479.90	**442.29**	*365.14*
72	90	13.84%	**165.27**	141.69	178.49	170.04	**158.37**	*127.94*
75	80	26.88%	**2,531.57**	1,830.09	2,305.44	2,884.54	**2,425.09**	*1,754.01*
75	85	17.83%	**662.51**	540.73	681.17	699.68	**634.77**	*512.36*
75	90	15.20%	**213.46**	180.02	226.77	221.39	**204.53**	*165.07*

Table B.3. Source: `Surface_Engine`*, rows 328–354. The heaped column reproduces the B.1 surface exactly.*

B.4 Reserving panel — Article 138 against a CBD 99.5% stress

Best-estimate liability at inception under central, Article 138 and CBD 99.5% bases, with the resulting longevity charges. The classifier is the parent paper's own: inadequate below 0.75, marginal 0.75 to 0.95, exceeds at 0.95 and above.

Entry	Vest	BEL central (€)	BEL Art.138 (€)	BEL CBD 99.5% (€)	SCR long Art.138 (€)	SCR long CBD (€)	Ratio	Verdict	v1.1.1 ratio	Change
60	75	-3,101	5,615	13,602	8,716	16,703	**0.5218**	**inadequate**	0.7134	-0.1916
60	80	-1,826	5,101	12,075	6,927	13,901	**0.4983**	**inadequate**	0.7099	-0.2116
60	85	-983	4,227	10,137	5,210	11,120	**0.4685**	**inadequate**	0.7043	-0.2358

60	90	-466	3,079	7,772	3,545	8,238	**0.4303**	**inadequate**	0.6949	-0.2646
63	75	-3,535	6,219	14,175	9,754	17,710	**0.5508**	**inadequate**	0.7129	-0.1621
63	80	-2,039	5,686	12,675	7,725	14,714	**0.5250**	**inadequate**	0.7093	-0.1843
63	85	-1,079	4,709	10,659	5,788	11,738	**0.4931**	**inadequate**	0.7034	-0.2103
63	90	-499	3,413	8,145	3,912	8,644	**0.4526**	**inadequate**	0.6936	-0.2410
65	75	-3,895	6,608	14,455	10,504	18,350	**0.5724**	**inadequate**	0.7125	-0.1401
65	80	-2,207	6,092	13,022	8,299	15,229	**0.5450**	**inadequate**	0.7088	-0.1638
65	85	-1,152	5,050	10,974	6,201	12,126	**0.5114**	**inadequate**	0.7028	-0.1914
65	90	-523	3,650	8,372	4,173	8,895	**0.4692**	**inadequate**	0.6927	-0.2235
68	75	-4,637	7,095	14,618	11,732	19,255	**0.6093**	**inadequate**	0.7615	-0.1522
68	80	-2,518	6,719	13,441	9,237	15,959	**0.5788**	**inadequate**	0.7582	-0.1794
68	85	-1,280	5,590	11,390	6,870	12,669	**0.5422**	**inadequate**	0.7530	-0.2108
68	90	-566	4,030	8,679	4,596	9,245	**0.4971**	**inadequate**	0.7441	-0.2470
70	75	-5,434	7,184	14,365	12,618	19,799	**0.6373**	**inadequate**	0.7975	-0.1602
70	80	-2,784	7,131	13,618	9,915	16,402	**0.6045**	**inadequate**	0.7946	-0.1901
70	85	-1,384	5,966	11,613	7,350	12,997	**0.5655**	**inadequate**	0.7900	-0.2245
70	90	-599	4,299	8,852	4,898	9,451	**0.5183**	**inadequate**	0.7822	-0.2639
72	75	-7,277	6,413	13,191	13,690	20,468	**0.6688**	**inadequate**	0.8366	-0.1678
72	80	-3,127	7,520	13,686	10,646	16,812	**0.6332**	**inadequate**	0.8343	-0.2011
72	85	-1,512	6,359	11,792	7,870	13,304	**0.5916**	**inadequate**	0.8304	-0.2388
72	90	-639	4,583	9,001	5,222	9,640	**0.5417**	**inadequate**	0.8239	-0.2822
75	80	-3,957	7,886	13,378	11,843	17,335	**0.6832**	**inadequate**	0.9006	-0.2174
75	85	-1,766	6,962	11,941	8,727	13,707	**0.6367**	**inadequate**	0.8982	-0.2615
75	90	-716	5,041	9,170	5,757	9,886	**0.5823**	**inadequate**	0.8941	-0.3118

Table B.4. Source: `Panel_Reserving`, rows 75–101. 27 of 27 cells inadequate.

The ratio falls at every cell, by between 0.14 and 0.31. The cause is the change of basis described above, not a change of calibration. The shape is preserved: the ratio still rises with entry age and falls with vesting age, so the standard formula remains least adequate for the youngest entrants with the longest deferrals.

B.5 Six worked examples

The six cases of §4 of the parent paper. Premiums are monthly and reflect each example's own income target, which is why they differ from the per-€1,000 figures in B.3. Every one of the six falls within the B.4 panel, so the reserving verdict is read from there; the adequacy ratio is a ratio of two charges that both scale with the benefit, so it is unaffected by the income level.

Ex	Entry	Vest	Income €/mo	Heaped (€)	Right-sized (€)	Zero (€)	Level 20% (€)	Industry ref (€)	*Equiv only*	Ratio	Verdict
1	60	80	500	**294.72**	287.95	257.24	324.05	309.65	*249.52*	0.4983	**inadequate**
2	65	85	1,000	**374.85**	365.04	326.10	410.80	392.54	*316.32*	0.5114	**inadequate**
3	70	85	1,000	**505.81**	482.32	430.87	542.79	518.66	*417.94*	0.5655	**inadequate**
4	70	75	500	**1,902.42**	1,547.83	1,382.72	1,741.87	1,664.46	*1,341.24*	0.6373	**inadequate**
5	60	85	2,000	**590.06**	581.80	519.74	654.74	625.64	*504.15*	0.4685	**inadequate**
6	60	90	1,000	**141.98**	140.70	125.69	158.33	151.30	*121.92*	0.4303	**inadequate**

Table B.5. Premiums from `Panel_Examples`; reserving from `Panel_Reserving`. Note that examples 1–3, 5 and 6 quote income in inception-dated terms per §4 of the parent paper, so their premiums are not directly comparable with B.3.

B.6 Capital requirement per cell

New in this edition. Day-1 own funds required per policy to hold SCR coverage at or above 100% at every valuation date, per €1,000 of monthly income at the vesting date. Each cell carries its own requirement profile computed at annual resolution to age 120, with its own SCR strip and Article 77b risk margin.

Entry \ Vest	75	80	85	90
60	23,251	21,189	18,616	15,307
63	22,949	20,783	18,322	15,151
65	22,673	20,499	18,051	15,054
68	22,152	20,177	17,624	14,883
70	21,514	19,913	17,368	14,726
72	20,346	19,606	17,096	14,513
75	—	18,895	16,769	14,154

Binding duration, in years from inception:

Entry \ Vest	75	80	85	90
60	7	13	18	25
63	5	10	16	23
65	4	8	15	21
68	2	5	12	18
70	2	4	10	17

72	1	3	8	15
75	—	2	6	12

Table B.6. Source: `Capital_Panel`. The entry 65 / vesting 80 cell reproduces an independently constructed single-cell block exactly, to a difference of 0.

The requirement per unit of benefit is flat. It ranges from €14,154 to €23,251 across twenty-seven cells spanning entry ages 60 to 75 and deferrals of three to thirty years — a factor of 1.64. The panel mean is €18,577 and the central case, entry 65 vesting 80, is €20,499, or +10.3% against the mean.

Two structural features follow. **The requirement falls with a longer deferral** and, more weakly, with a later entry age — so the design is least capital-hungry precisely where B.1 shows it is cheapest. And **the binding duration is not a fixed fraction of the deferral — the ratio of binding year to deferral runs from 0.29 at the shortest deferrals to 0.85 at the longest, rising throughout**, which is why the profile is computed annually: at five-year sampling most of these peaks would fall between samples.

The central case is therefore **representative rather than favourable**. The €36,780 requirement reported in the parent paper for the central case is not an artefact of the entry and vesting ages chosen.

Companion workbook: `MWP-2026-04_Audit_Workbook_v14.2.0.xlsx`. Sheet references are given beneath each table. The workbook contains no computed value that is not a live formula.

Mylife.ie · MWP-2026-04 Annex B · Full pricing and reserving surface · Version 2.1.0, July 2026 SMP Financial Ltd, Dublin · CBI C42382

Annex C — Primary sources

Version 2.0.0, July 2026. Supersedes the edition shipped with MWP-2026-04 v1.1.1. Four changes: the ILT17 amendment date added, the CMI convergence-structure description and the Human Mortality Database added to §C.1, the specific EIOPA extract added to §C.2, and the companion-workbook reference in the Use of AI statement corrected from the superseded Phase F workbook to the current audit workbook.

C.1 Mortality

- CSO Irish Life Tables No.17, 2015–2017. Statistical release 7 July 2020, amended 9 November 2020 (revisions to calculation methods for ages 99 and above): https://www.cso.ie/en/releasesandpublications/er/ilt/irishlifetablesno172015-2017/
- Society of Actuaries in Ireland — IILMI Longevity Investigation 2009–2015 (published March 2019): https://web.actuaries.ie/
- CMI Ltd. Working Paper 177 (CMI_2022 model, June 2023): https://www.actuaries.org.uk/learn-and-develop/continuous-mortality-investigation
- CMI Mortality Projections Committee — published description of the model's convergence structure: the long-term rate applies to age 85 and falls linearly to nil at age 110, and convergence uses a cubic polynomial. Relied on in §6.3 to verify the projection layer independently: https://www.actuaries.org.uk/learn-and-develop/continuous-mortality-investigation
- Human Mortality Database. Max Planck Institute for Demographic Research (Germany), University of California Berkeley (USA), and INED (France). Available at https://www.mortality.org/. England & Wales series 1×1, used for the Cairns–Blake–Dowd calibration in Annex A; England & Wales data last modified 31 January 2025, Ireland 23 January 2025, accessed 19 June 2026.
- Cairns, A.J.G., Blake, D. and Dowd, K. (2006). "A Two-Factor Model for Stochastic Mortality with Parameter Uncertainty: Theory and Calibration." *Journal of Risk and Insurance*, 73(4), 687–718. https://doi.org/10.1111/j.1539-6975.2006.00195.x

C.2 Discounting

- EIOPA Risk-Free Interest Rate Term Structures, EUR no-VA, 31 May 2026 (published 3 June 2026): https://www.eiopa.europa.eu/tools-and-data/risk-free-interest-rate-term-structures_en
- The specific extract relied on: archive `EIOPA_RFR_20260531.zip`, workbook `EIOPA_RFR_20260531_Term_Structures.xlsx`, sheet `RFR_spot_no_VA`, column *Euro* — 150 published annual spot rates. All curve parameters are read from that file: last liquid point 20 years, convergence period 40 years, ultimate forward rate 3.30%, Smith-Wilson alpha 0.059979, credit risk adjustment 10 basis points.

C.3 Loadings — Irish SFCRs year-end 2024

- Royal London Insurance DAC SFCR 2024: https://www.royallondon.ie/siteassets/site-docs/about-us/sfcr/rl-ireland-

sfcr-ye2024.pdf
- Aviva Life & Pensions Ireland DAC SFCR 2024: https://static.aviva.io/content/dam/aviva-public/ie/pdfs/aviva-life-pensions-ireland-sfcr-2024.pdf
- Irish Life Assurance plc SFCR 2024: https://www.centralbank.ie/docs/default-source/regulation/industry-market-sectors/insurance-reinsurance/solvency-ii/sfcr-2024/irish-life-assurance-plc-sfcr-2024.pdf
- New Ireland Assurance Company plc SFCR 2024: https://www.centralbank.ie/docs/default-source/regulation/industry-market-sectors/insurance-reinsurance/solvency-ii/sfcr-2024/new-ireland-assurance-company-plc-sfcr-2024.pdf
- Zurich Life Assurance plc SFCR 2024: https://www.zurich.ie/-/media/project/zurichie/zurichmainsite/files/sfcr-2024/sfcr-zurich-life-assurance-plc-2024.pdf
- Standard Life International DAC SFCR 2024: https://www.centralbank.ie/docs/default-source/regulation/industry-market-sectors/insurance-reinsurance/solvency-ii/sfcr-2024/standard-life-international-designated-activity-company-scfr-2024.pdf
- Milliman Ireland — Analysis of Solvency and Financial Condition Reports for Irish life insurers YE 2024 (May 2025): https://media.milliman.com/v1/media/edge/images/millimaninc5660-milliman6442-prod27d5-0001/media/Milliman/PDFs/2025-Articles/5-21-25_Ireland-SFCR-Report-YE-2024.pdf
- PwC Ireland — Insurance sector lapse risks (2024–2025): https://www.pwc.ie/services/audit-assurance/insights/insurance-sector-lapse-risks.html
- Society of Actuaries in Ireland — Financial and Economic Assumptions and Principles (March 2024): https://web.actuaries.ie/sites/default/files/2024-03/Financial%20%20Economic%20Assumptions%202024_final.pdf

C.4 Solvency II

- Directive 2009/138/EC (consolidated): https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX:02009L0138-20210630
- Commission Delegated Regulation (EU) 2015/35 (consolidated): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02015R0035-20230101
- EIOPA Rulebook, Article 55 (Lines of Business): https://www.eiopa.europa.eu/rulebook/solvency-ii/article-2468_en
- S.I. No. 485 of 2015 (Irish transposition): https://www.irishstatutebook.ie/eli/2015/si/485

C.5 Irish pensions law and Revenue

- Taxes Consolidation Act 1997, Part 30: https://www.irishstatutebook.ie/eli/1997/act/39/
- Revenue Pensions Manual Chapter 23 (ARFs): https://www.revenue.ie/en/tax-professionals/tdm-wm/pensions/chapter-23.pdf
- Revenue Pensions Manual Chapter 24 (PRSAs): https://www.revenue.ie/en/tax-professionals/tdm/pensions/chapter-24-20240419100120.pdf
- Revenue Pensions Manual Chapter 28 (Imputed Distributions): https://www.revenue.ie/en/tax-professionals/tdm-wm/pensions/chapter-28.pdf
- Pensions Act 1990: https://www.irishstatutebook.ie/eli/1990/act/25/
- S.I. No. 128 of 2021 (IORP II transposition): https://www.irishstatutebook.ie/eli/2021/si/128/made/en/print
- Finance Act 2024: https://www.irishstatutebook.ie/eli/2024/act/43/enacted/en/print
- Pensions Authority — trustee investment guidance: https://www.pensionsauthority.ie/trustees/investment/

C.6 Consumer protection, IDD, PRIIPs

- S.I. No. 229 of 2018 (IDD transposition): https://www.irishstatutebook.ie/eli/2018/si/229/made/en/print
- S.I. No. 80 of 2025 (CPC 2025 — Standards for Business): https://www.irishstatutebook.ie/eli/2025/si/80/made/en/print
- S.I. No. 81 of 2025 (CPC 2025 — Consumer Protection Regulations): https://www.irishstatutebook.ie/eli/2025/si/81/made/en/print
- Central Bank CPC 2025 press release (24 March 2026): https://www.centralbank.ie/news/article/press-release-how-the-consumer-protection-code-secures-your-interests-24-march-2026
- PRIIPs Regulation (EU) No 1286/2014 (consolidated): https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:02014R1286-20191230
- EIOPA 2022 Technical Advice on the PRIIPs review (April 2022): https://www.eiopa.europa.eu/system/files/2022-04/esa_advice_on_the_review_of_the_priips_regulation.pdf

C.7 AML, GDPR, general insurance

- Criminal Justice (Money Laundering and Terrorist Financing) Act 2010: https://www.irishstatutebook.ie/eli/2010/act/6/enacted/en/html
- Data Protection Act 2018: https://www.irishstatutebook.ie/eli/2018/act/7/

About the author

Donal Milmo-Penny, QFA FLIA, is the founder of Mylife.ie and Research Lead of the Mylife.ie Working Paper Series. He is a founding partner of SMP Financial Ltd, a financial services firm regulated by the Central Bank of Ireland (C42382). His public professional profile records twenty-five years of business experience in life assurance, pension and inheritance planning for Irish individuals, families, professionals and business owners. He has previously served as President / Chairman of the Professional Insurance Brokers Association (PIBA), as a Director of Brokers Ireland, and as a member and former Chair of Brokers Ireland's Legislation and Compliance Committee. He is listed on the Main Board of Brokers Ireland representing SMP Financial Ltd. His professional qualifications include the Qualified Financial Adviser (QFA) and Fellow of the Life Insurance Association (FLIA) designations.

About Mylife.ie Research

Mylife.ie is a trading name of SMP Financial Ltd. The Mylife.ie Working Paper Series is the firm's research publication channel for technical analyses of Irish life-assurance, mortgage-protection, pension and inheritance-planning topics. The series is intended for an audience of actuaries, regulators, brokers, financial advisers, and informed consumers. Working papers are subject to internal review at SMP Financial Ltd prior to publication. Series papers are made available at mylife.ie/research.

Remuneration disclosure

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Use of AI

This paper was drafted with the assistance of an AI research-and-writing tool acting under the direct supervision of the author. The tool was used to compile and synthesise the primary-source evidence reviewed throughout the paper, to construct the pricing, reserving and stochastic mortality calculations documented in §§3, 6 and 7 and in Annex A, and to draft the prose under the author's direction and review.

All numerical results are reproduced in the companion workbook, `MWP-2026-04_Audit_Workbook_v10.0.0.xlsx`. That workbook contains no computed value that is not a live formula: there is no reproduction code to publish, because the model is the workbook. Its mortality basis is derived from the CSO's published ILT17 table upward rather than read from a supplied file, and its discount curve is taken from the EIOPA publication; both derivations carry live verification ties. The workbook additionally carries fifteen classified proofs, each labelled as substantive, identity or sensitivity so that no check reads as stronger than it is.

All source citations were verified at the URLs given in Annex C. The author retains full editorial and professional responsibility for the paper's content, conclusions, and any errors of fact, interpretation, or judgement.

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MWP-2026-04 — Annex D: Workbook Guide

Version 1.0.1 · July 2026 · Companion to `MWP-2026-04_Audit_Workbook_v14.2.0.xlsx`

This annex is a reader's guide to the audit workbook for human and AI readers: how to navigate it, how its engines are laid out, the conventions its numbers depend on, and the features that look like errors but are deliberate. It describes the workbook as it stands. Change history is not recorded here — it lives on the `Version` sheet and in the erratum.

D.1 First five minutes

1. **`Version`** — current version, status, and the full changelog. Confirm the version you hold is the one you intend to work on.
2. **`Layout_Registry`** — the occupied row ranges, last used row and safe start row for every sheet, and the named figures each sheet carries. Consult it before writing to any sheet; refresh it after.
3. **Recalculate** and confirm zero errors: `python3 recalc.py <file>`. The workbook recalculates cleanly; any error is a regression.
4. **Confirm the anchors by defined name**, never by coordinate: `fig_premium`, `fig_mwr`, `fig_day1_exact`, `fig_bind_duration`, `fig_ratio_138_cbd`, `fig_cohort_le` (§D.4 gives the full register and current values).
5. **`Index`** — the block map of every sheet, generated; use it to locate content by label.

D.2 The model in brief

The workbook prices and reserves a regular-premium deferred lifetime annuity inside the Irish ARF / vested-PRSA wrapper: forfeitable on lapse, premiums retained by the risk pool. Central case: entry 65, vesting 80, €400,000 fund, 4% payout. Mortality is **derived** — CSO ILT17 (amended edition) × IILMI selection × a CMI_2022-style projection rebuilt from a Cairns–Blake–Dowd calibration — never read from a supplied matrix; the discount curve is the published EIOPA EUR no-VA structure of 31 May 2026. Two findings govern the paper: the product prices fairly but cannot be written on standard-formula capital (€36,779.69 of day-one own funds per policy against €3,913.27 of lifetime margin), and the Article 138 longevity stress delivers 0.545 of a stochastic 99.5% charge for this liability profile.

D.3 Architecture

Flow: **sources** (`ILT17_Source`, `EIOPA_Source`, CBD parameters) → **derivation** (`CMI_Projection`, `Cohort_Survival`, `Discount`, `Discount_Monthly`) → **annual engine** (`Projection` → `Pricing`, `ANAV`, `Reserving`, `OwnFunds_SCR`, `RiskMargin`, `Trajectory`, `Reconciliation`) → **monthly engine** (`Projection_M` → `Pricing_M`, `Reserving_OF_M`, `Capital_M`, `Validation_M`) → **analysis** (commission, forfeiture, mutualisation, adequacy, panels, frontier, sensitivities, reinsurance).

Group	Sheets and roles
Audit & navigation	`Version` changelog · `README` orientation · `Layout_Registry` write-safety map · `Index` block map · `Proofs` fifteen classified checks
Sources & verification	`ILT17_Source` CSO table + selection + Kannisto fit · `EIOPA_Source` published curve + parameters · `EIOPA_Verification` Smith-Wilson closed-form test · `Mortality_Matrix` independent comparator only · `Mortality` presentation
Mortality derivation	`CMI_Projection` full projected surface from the CBD calibration · `Cohort_Survival` cohort diagonals, survival, life expectancies
Discounting	`Discount` annual DF · `Discount_Monthly` log-linear monthly DF
Annual engine	`Assumptions` all parameters · `Projection` 56-year cashflow grid · `Pricing` premium solve · `ANAV` fund check · `Reserving` BEL · `OwnFunds_SCR` stressed BELs, SCR, coverage · `RiskMargin` full SCR strip and risk-margin run-off, three reinsurance routes · `Trajectory` the exact requirement profile — authoritative · `Reconciliation` identities and decompositions
Monthly engine	`Projection_M` 661-month grid with stressed paths · `Pricing_M` monthly premium · `Reserving_OF_M` · `Capital_M` monthly SCR, risk margin and requirement · `Validation_M` monthly-vs-annual decomposition
Analysis	`Commission_Models` structures, candidates, exact-SCR block · `Forfeiture_Basis` · `Mutualisation` receipts and subsidy · `Adequacy` Article 138 vs CBD 99.5%, production basis · `CBD_Stochastic` stochastic pack and Annex A reconstruction · `Panel_Reserving` 27-cell adequacy · `Capital_Cell` single-cell proving block · `Capital_Panel` 27-cell capital requirement · `Surface_Engine` 16×16 surfaces and Annex B grids · `Panel_Examples` six worked cases · `Lapse_Routes` · `Sensitivities` margins, post-reform, cost of cover · `Fairness` money's-worth tests · `Test_C` · `Frontier` / `Frontier_Curve` uplift frontier · `Reinsurance`

D.4 Reading figures — the register

Reported figures are `fig_*` names; internal checks are `tie_*` names. Read by name.

Headline values as at v14.1.0: premium €12,316.07 p.a. / €1,003.26 monthly · MWR 0.8952 · day-one requirement €36,779.69 exact, binding at 8 (sampled €36,744.48; monthly basis €36,317.92 at 10) · risk margin t=0 €20,767.45 · own funds t=0 €3,913.27 · Article-138÷CBD ratio 0.545 · panel €14,154–€23,251, mean €18,577 · maximum fair premium €12,250.22 · recommended-structure cost €251.87 interpolated / €253.05 exact · post-reform (CoC 4.75%) €32,837.52, binding at 10 · capital per €1 of margin at 2% 15.13 · mutualisation subsidy 24.2% · cohort LE at entry 24.0879.

Name	Cell	Meaning
fig_premium	Pricing!B14	annual premium, equivalence plus loadings
fig_premium_monthly	Pricing_M!B13	monthly premium, fully-monthly basis
fig_mwr	Fairness!B3	money's-worth ratio (mortality-only pools)
fig_prem_fund	Fairness!B4	premium as a share of the fund
fig_day1_exact / fig_bind_duration	Trajectory!B164 / B165	exact day-one requirement and its binding duration
fig_day1	Frontier!B23	day-one requirement, five-point sampled basis
fig_day1_monthly / fig_bind_monthly	Capital_M!B125 / B126	requirement and binding duration, monthly basis
fig_of_t0 / fig_of_t15	OwnFunds_SCR!B7 / E7	own funds at t = 0 and t = 15
fig_scr_t10	OwnFunds_SCR!D23	aggregated SCR at t = 10
fig_rm_t0	OwnFunds_SCR!B30	risk margin at inception
fig_req_excl_rm	Reconciliation!B52	requirement excluding the risk margin
fig_of_runoff	Reconciliation!B53	own funds accumulated to run-off
fig_scale_capital	Reconciliation!B54	book-level capital, €m per 1,000 policies
fig_commission_pv	Reconciliation!B56	commission present value, euro
fig_ratio_138_cbd	Adequacy!B179	Article 138 ÷ CBD 99.5% charge, liability-weighted
fig_cohort_le	Cohort_Survival!G71	cohort life expectancy at entry 65
fig_pool_vest	Projection!F19	in-force pool at vesting
fig_deferral	Assumptions!B6	deferral, years
fig_maxfair_premium	Commission_Models!B172	maximum premium at the 0.90 fairness floor
fig_capital_cost_chosen / _exact_scr	Commission_Models!B284 / B542	recommended-structure capital cost, interpolated / exact
fig_capital_per_margin_2pc	Sensitivities!G91	capital per €1 of margin at a 2% margin
fig_req_postreform	Sensitivities!B36	requirement at CoC 4.75%, maximum of the full profile
fig_subsidy_pct	Mutualisation!B41	mutualisation subsidy share of a survivor's contribution
fig_cell_req	Capital_Cell!B77	single-cell requirement, proving block
fig_panel_req_min/max/mean/central	Capital_Panel!B1736/1735/1738/1739	panel requirement statistics
fig_panel_inadequate	Panel_Reserving!B115	count of inadequate panel cells

Ties (expected values in §D.7): tie_derivation Assumptions!B64 · tie_cmi CMI_Projection!B153 · tie_le_anchors Cohort_Survival!B78 · tie_presentation Mortality!B64 · tie_monthly_grid Validation_M!B9 · tie_annual_control Commission_Models!B388 · tie_scr_construction Commission_Models!B533 · tie_margin_control Sensitivities!B185 · tie_margin_ownfunds Sensitivities!B189 · tie_postreform_sanity Sensitivities!B264 · tie_panel_central Panel_Reserving!B130 · tie_panel_cell Capital_Panel!B1745 · tie_cell_vs_annual Capital_Cell!B85 · tie_annexb Surface_Engine!B304 · tie_frontier_routes / _u0 / _monotone Frontier_Curve!B45 / B52 / B57.

D.5 Column guides

Full guides sit beneath each engine sheet at the rows below; the essentials:

`Projection` **(guide at rows 71–101).** Rows 4–59 are policy years 1–56, ages 65–120. A year · B age · C cohort qx · D gross lapse ladder · E net lapse (× 0.70) · F in-force pool · G mortality-only survival · H discount factor · I premium PV/unit · J forfeiture diagnostic · K payout PV (escalated 2% **from inception**) · L expense PV (€82 × 1.025^year) · M/N asset cashflow and its PV · O/P liability cashflow and its PV · Q/R Article-138 pool and liability PV · S/T lapse-up · U/V lapse-down · W Article 140 liability PV · X/Y mortality-only premium and payout PVs (money's-worth legs) · Z–AD premium and commission PVs in euro by pool and schedule.

`Projection_M` **(guide at 677–701).** Rows 7–667 are months 0–660. Per-unit columns are per €1 of monthly premium; N, O and the stressed liability columns are euro. Decrements are constant-force monthly conversions of annual rates; the discount factor is log-linear between annual nodes; month 0 carries the full year-one commission (100% × 12 units).

`RiskMargin` **(guide at 69–89).** Rows 4–59 are durations 0–55. B–F: BELs central / 138 / lapse-up / lapse-down / 140, the stressed three prospectively renormalised × F(t)/pool(t). G–I: SCR components (the mass-lapse term inside H is gated to the deferral). J–L: aggregate, discounted aggregate, risk margin. M–P and Q–T: the reinsured and uncedable-floor routes.

`Capital_M` **(guide at 163–173).** Rows 6–61 are annual points on the monthly grid. **C is ANAV and D is BEL.** E–H stressed BELs, I–N the SCR stack mirroring `RiskMargin`. Rows 66–121 hold the requirement profile; B125/B126 its maximum and binding duration.

D.6 Conventions the numbers depend on

Timing. Annual engine: payments annually in advance; the discount factor on a row is DF(year − 1). Monthly engine: twelfths in advance; CPI steps at policy anniversaries. **Escalation exponents.** The payout escalates from **inception**: (1.02)^(age − entry). The expense escalates by **policy year**: (1.025)^(year), so year one is €82 × 1.025. **Stressed BELs.** At duration t a stressed BEL is the stressed-pool liability PV rescaled to the central pool: × F(t)/pool_stressed(t). Article 138 stresses mortality only (q × 0.8); the lapse stresses leave mortality central. **Mass lapse.** The 40% mass-lapse sub-stress is non-zero only while the BEL is negative, hence only inside the deferral; the run-off strip gates it

explicitly. **CBD horizons.** The `CBD_Stochastic` illustrative path accrues parameter uncertainty from the 2022 calibration for a cohort commencing 2022 (√h). The production test on `Adequacy` values the cohort commencing 2026 (√(4+h)). The production basis governs `fig_ratio_138_cbd`. **κ anchor.** The projection anchors on the fitted 2022 κ from the Annex A calibration (`params_ew.csv`), not the trend construction $\kappa_{2019}+3\mu$; the anchor notes on `CMI_Projection` and `CBD_Stochastic` state the quantified sensitivity (premium +€5.60, requirement +€7.90, ratio 0.542 vs 0.545 on the alternative; verdicts unchanged). **Panel units.** Panel and surface figures are per €1,000 of monthly income at vesting. Because the administration expense is a fixed euro amount, premiums are **not** proportional to income — do not rescale a cell to another income level by ratio. **One basis at a time.** The requirement exists on three bases: exact annual-resolution (authoritative, `Trajectory`), five-point sampled (legacy comparisons), and interpolated (the candidate table). Never difference figures computed on different bases; when quoting a capital cost, quote the exact figure (`fig_capital_cost_exact_scr`).

D.7 By design, not defects

- **`ANAV!B12` reads FAIL.** It is a demonstration: the superseded engine's ANAV(15) tested against a sanity floor it cannot meet. The corrected figure in B11 passes. Exactly one FAIL exists in the workbook, and it is this one.
- **Four NON-MONOTONE flags** (`ILT17_Source` J51:J52, `Mortality` E44:E45). The published CSO table is itself non-monotone at ages 104–105 (amended edition verified); the flags mark inherited data, not a transcription error.
- **Eighteen BREACHES FLOOR verdicts** on `Frontier_Curve` and **one NO** at `Sensitivities!D90`. These are the paper's central finding — the money's-worth ratio below the 0.90 floor — restated live, not failures.
- **Negative premiums in the `Surface_Engine` corners** (entry 74/vest 75; 75/76). Premium terms under two years have no heaped-commission solution (boundary: commission factor = 1 − margin); the cells hold meaningless roots and should be read as blank. The note at A377 marks the region.
- **Roughly 725 formula cells display blank.** Conditional display (survival triangles, vesting markers, age-gated verdicts) — present and correct, intentionally empty.
- **Documented tie residuals.** `tie_cmi` ≈ 4.3×10^{-8} (rebuilt surface vs the supplied comparator, rounding of supplied parameters); `tie_panel_central` ≈ -4.1×10^{-5} (panel vs annual, per-cell construction); `tie_cell_vs_annual` ≈ €5.28, 0.014% (fixed-expense scaling residual between the per-€1,000 cell and the central policy); `tie_margin_ownfunds` ≈ 3×10^{-11} (floating-point residue). **Every other tie returns exactly zero.** These values are the documented ones; a checker who "repairs" them has broken something.

D.8 Working protocols

1. Consult `Layout_Registry` before writing to any sheet; place new blocks at the safe start row; refresh the registry after.
2. Locate blocks by their labels, never by row-offset arithmetic from another block.
3. Restrict any find-and-replace to cells whose value begins with `=`.
4. Version every issue — MAJOR if reported figures change, MINOR if additive, PATCH if cosmetic — as a new file; never overwrite.
5. Recalculate and confirm zero errors before issue; then confirm the anchors by name and expect exactly the intended movers.
6. Make traceability checks precision-aware: tolerance follows the decimals at which a figure is quoted (±0.5 for an integer, ±0.005 at two decimals).
7. Ship every new computational block with a tie that would fail if the block were wrong, and classify it honestly — substantive, identity, or sensitivity.
8. Verify against source, not against a producer's own output: reproducing a supplied file proves ingestion, not correctness.
9. Take extrema from full profiles. Peaks fall between five-year samples; the exact profile on `Trajectory` (and its per-cell counterparts) is authoritative.
10. Face labels carry no version references; record change on `Version` and in the erratum.

D.9 Notes for AI readers

Treat the workbook as the source of truth and verify by **recomputation**, not resemblance: rebuild a quantity from its inputs and compare, rather than judging a formula by its shape. Expect the by-design features of §D.7 and do not "correct" them. The mortality basis is derived from `ILT17_Source` upward; `Mortality_Matrix` is a comparator only — never wire production to it. Read cell values at full precision; truncated displays can drop exponents and invert a conclusion. When comparing your own reconstruction to the sheets, match the stated convention first (timing, exponent base, renormalisation, horizon, anchor, units) — a mismatch usually means your convention, not the workbook's arithmetic. After any modification: recalculate, confirm zero errors, re-read all fifty names, and account for every mover. Respect

the design decisions recorded in the project handover; they are not yours to reverse silently.