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RISING INTEREST RATE ENVIRONMENT

How should life insurers manage “convexity risk” as interest rates rise?

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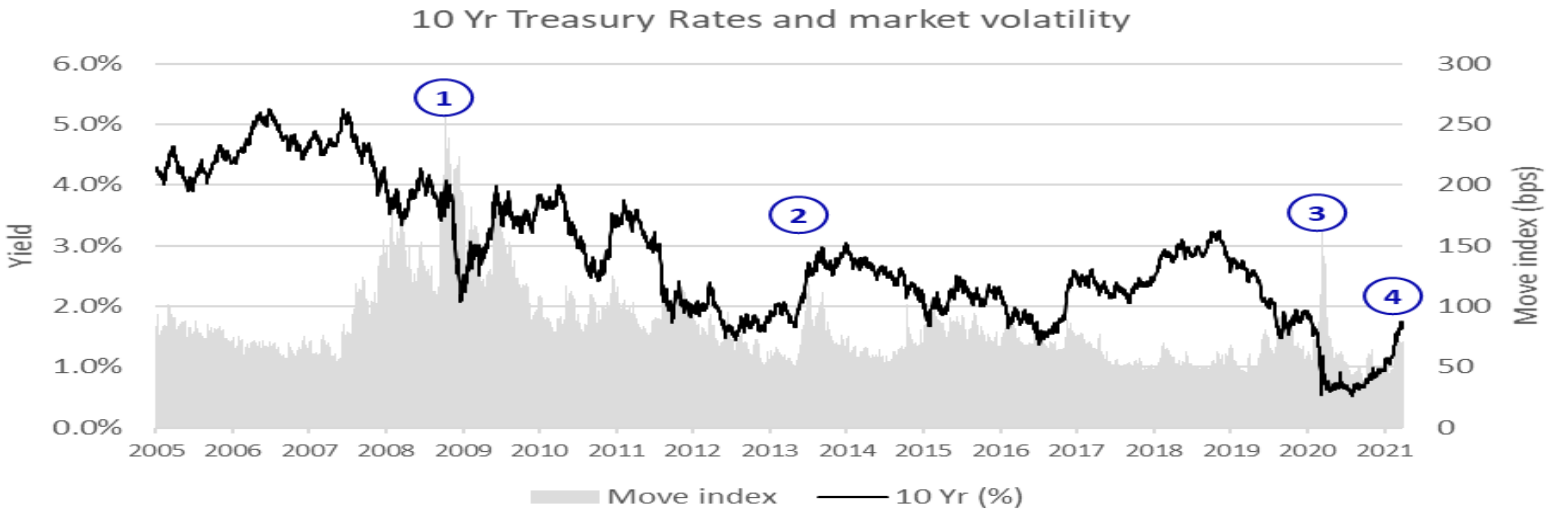
HISTORICAL 10Y TREASURY RATES AND MARKET IMPLIED VOLATILITY

10Y Treasury rate has increased up by 81bps in Q1 2021, but implied interest rate volatility in derivative prices has been stable



Historical event	Maximum IR change	Max volatility
1: Global financial crisis (2008 – 2009)	-204bps	264bps
2: Fed's tapering of bond purchasing program (2013)	+138bps	118bps
3: COVID-19 stress (2020)	-136bps	163bps
4: Latest increase in interest rates (2021)	+81bps	76bps

The Fed's monetary actions, such as setting the target benchmark rate and the decision of when to taper the bond purchase program, are more directly related to interest rate changes

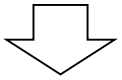
RISING INTEREST RATE ENVIRONMENT – WHAT IS UNIQUE THIS TIME?

Inflationary factors

- **COVID-19 recovery**: if the COVID-19 pandemic is effectively terminated, US consumer spending may surpass available supply, which would be extraordinary
- **Legislative stimulus**: the President's $1.9 trillion financial stimulus and $3 trillion infrastructure development plans are the biggest in history
- **Restricted monetary levers**: the Fed could be forced to taper open market operations at some point due to the volume of debt held[1]
- **Aging workforce**: demographically dominant baby-boomers are entering normal retirement age although mitigated by many deciding to work longer; the net impact may be a labor shortage

Financial market's expectation

- **Market expectation**: the 10-year forward interest rate over a 1-year horizon is 2.03%[2] and expected inflation at ~1.5%[3] is lower than the Fed's 2.0% target
- **Stable current market volatility**: interest rate volatility implied in derivative prices has been stable and the probability that 10-year Treasury rates will increase by 100bps is estimated to be less than 5%
- **Expansionary monetary policy**: the Fed has reduced its target benchmark rate to the historically low level of between 0% and 0.25% and will continue to buy at least $120 billion[4] of bonds each month until recovery is complete
- **Unemployment rate**: The unemployment rate is relatively high, at 6.0%[5], reducing the pressure to increase wages



An abrupt increase in inflation and interest rates may be triggered if consumers and corporations integrate inflation expectations into their decisions

Note(s) [1] The current debt balance is approximately $7.7 trillion as of April 2021, the Federal Reserve's website [2] As of 3/31/2021 [3] 10-year expected inflation, Federal reserve bank of Cleveland as of March 2021 [4] $80 billion of Treasury securities and $40 billion of mortgage-backed debt [5] Bureau of labor statistics as of March 2021

TAIL RISK – CONVEXITY AND LIABILITY EMBEDDED OPTIONS

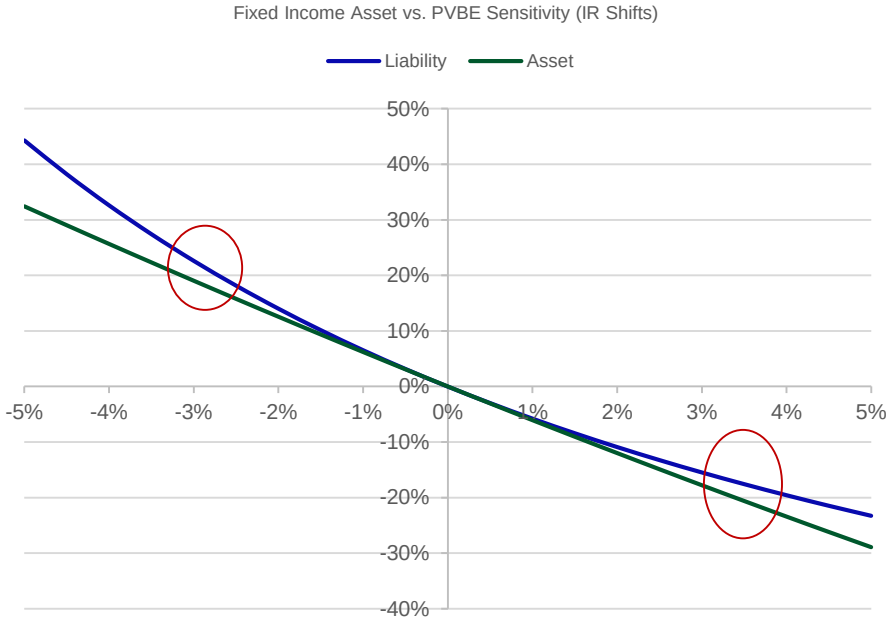
Life insurers' ALM position is vulnerable to short-term interest rate spikes due to its large convexity and dynamic lapse behavior under rising interest rate environment

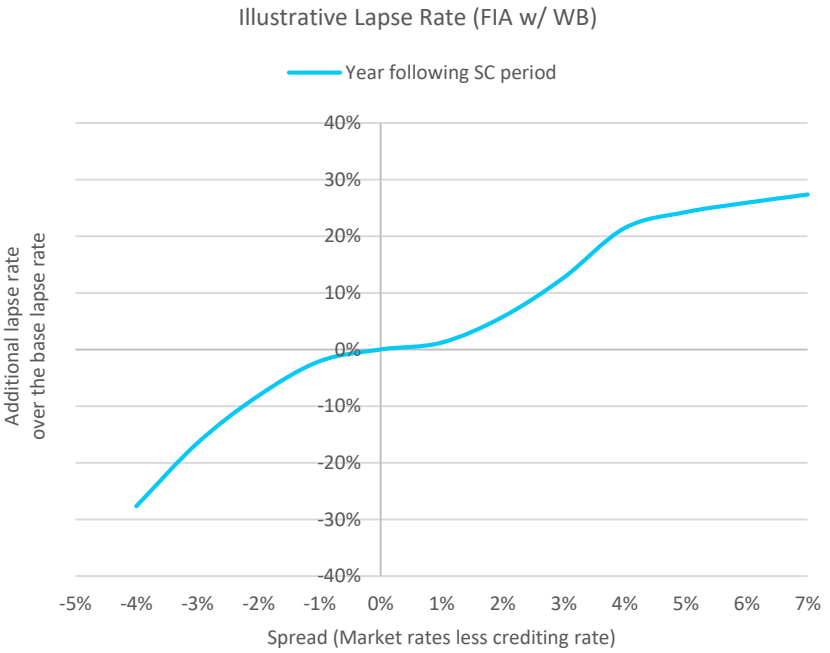
Static convexity

- This metric quantifies the change in liability sensitivity, in terms of the present value of best-estimate liability cash flows relative to changes in interest rates without incorporating dynamic lapse behavior

Dynamic liability convexity

- This metric quantifies the deviation from static liability convexity due to dynamic policyholder lapse



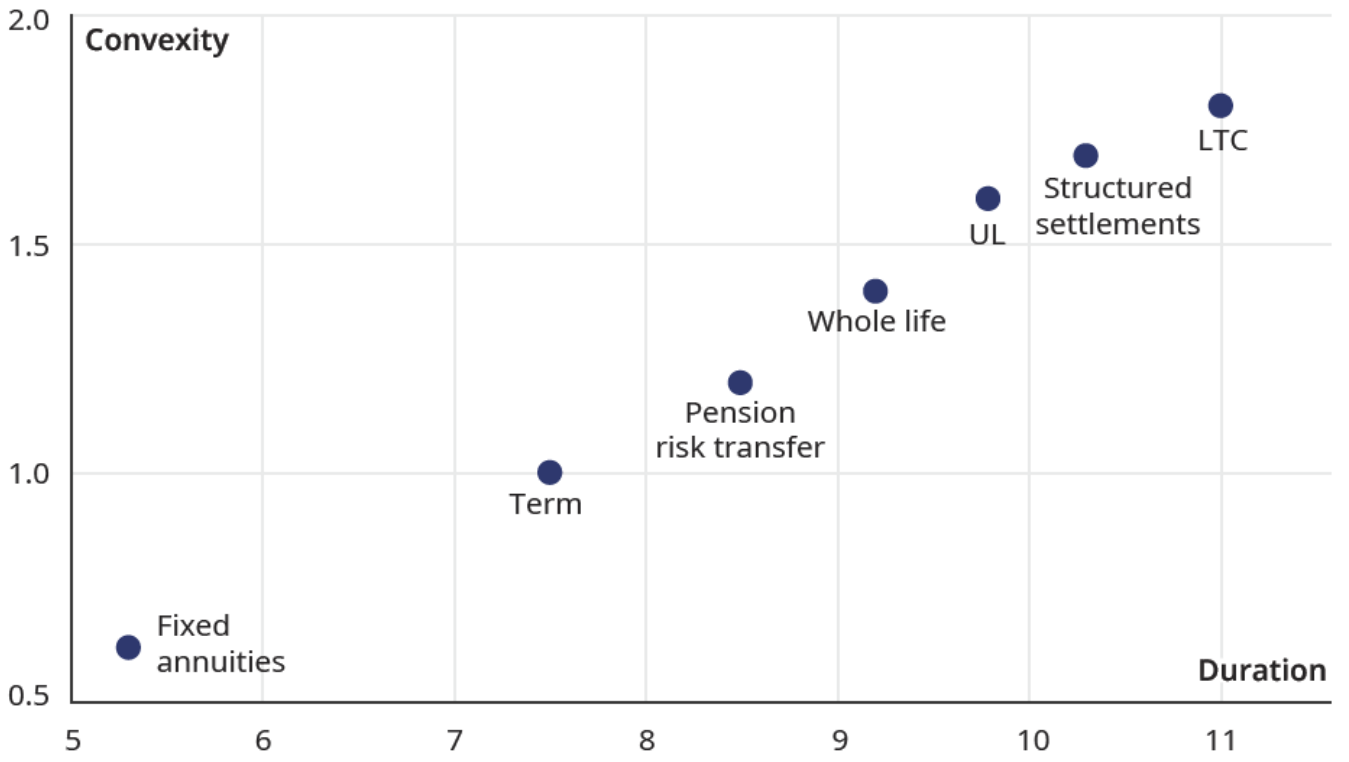


The key implication is that life insurers would not be compensated for convexity risk, and it is critical to review its convexity exposure especially under rising interest rate environment

LIABILITY DURATION AND STATIC CONVEXITY BY PRODUCTS

Liability sensitivity to the change in interests without incorporating dynamic lapse under best-estimated assumptions

Illustrative liability duration and convexity[1]



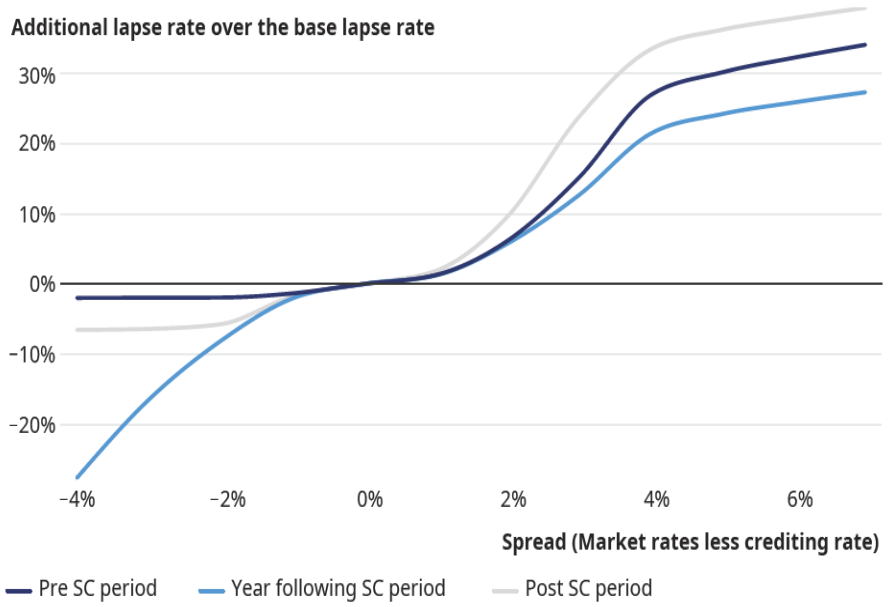
Static liability convexity increases with the longer liability cash flows

Note(s) [1] OW's analysis

DYNAMIC LAPSE

Positive competitive spreads and downside direction post surrender charge (SC) period increase the dynamic lapses

Illustrative dynamic lapse rate[1]



Dynamic lapse

- Generally sensitive to positive competitive spreads for all cases; also sensitive in downside direction in the year following the end of the surrender charge period
- Policyholders do not react to small competitive spreads – lapse sensitivity increases when the spread widens (say by more than 100bps) in either direction
- Lapse rates flatten out at extreme competitive spreads
- Sensitivity is asymmetric – for lapse behavior, policyholders generally react more to uncompetitive product rates than overly competitive rates
- Reduction to lapse rates are bounded by zero but increases to lapse rates are effectively unbounded (capped at 100% only)
- There is relatively little burnout (insensitivity of the remaining cohort due to prior selective activity) in existing blocks of liabilities today because rates have remained stable and low for a long time.

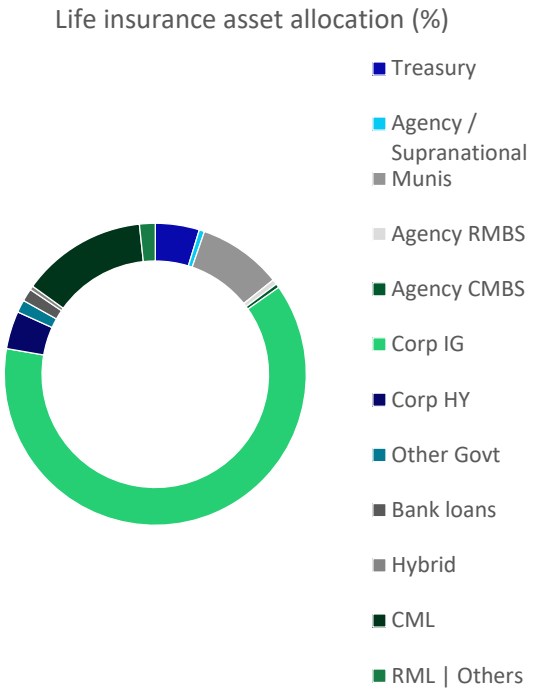
Dynamic lapse hurts the life insurers' financial position and contributes to the higher convexity under the sudden changes in the market interest rates

Note(s) [1] OW's analysis, industry range

LIFE INSURANCE INDUSTRY ASSET ALLOCATION

The industry aggregate asset portfolio may have less convexity than all liability types, which are illustrated in the previous slide, except for fixed annuities

Life insurance industry asset allocation [1] and benchmark indexes[2]



Asset class	Allocation %	Market indices[3]	YTW	Maturity	OAS (bps)	Duration	Convexity
Treasury	4.7%	US Treasury	1.00%	8.0	-1	6.79	1.01
Agency / Supranational	0.6%	US Agency	0.80%	5.0	4	3.91	-0.53
Munis	9.0%	US Muni Bond (Taxable)	2.49%	16.0	N/A	9.80	1.00
Agency RMBS	0.6%	US MBS	1.82%	5.6	12	4.09	-1.81
Agency CMBS	0.4%	US CMBS	1.50%	6.3	37	5.81	0.45
Corp IG	62.5%	US Credit/Corporate (IG)	2.28%	12.0	91	8.48	1.35
Corp HY	4.0%	US Corporate High Yield	4.23%	6.5	310	3.87	-0.11
Other Govt	1.4%	Emerging Market Debt	4.01%	10.4	279	6.68	0.94
Bank loans	1.4%	US Corporate High Yield	4.23%	6.5	310	3.87	-0.11
Hybrid	0.4%	U.S. ABS Floating Rate	0.67%	5.3	56	0.05	0.05
CML	13.4%	US Corporate High Yield	4.23%	6.5	310	3.87	-0.11
RML | Others	1.7%	US Corporate High Yield	4.23%	6.5	310	3.87	-0.11
Total	100.0%		2.52%	10.6	124	7.04	0.81

Convexity matching should be always considered in the asset optimization process regardless of the interest rate environment life insurers are operating under as life insurers would not be compensated for convexity risk

Note(s) [1] S&P Market Intelligence, SNL data as of 12/31/2020 [2] Bloomberg data as of 3/31/2021 [3] Bloomberg data as of 3/31/2021

IMPLICATION FOR ASSET ALLOCATION AND HEDGING

01

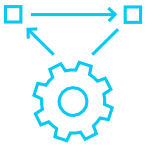
Reduce negative convexity assets

- Reduce exposure to asset classes that have negative convexity, such as Agency RMBS
- Optionality in callable bond and mortgage portfolios exacerbate life insurers' convexity risk

02

Portfolio optimization

- Asset optimization with both duration and convexity matching vs. "static duration and convexity" of liabilities
- The convexity mismatch would cause an issue to life insurers under both rising and declining interest rate scenarios



03

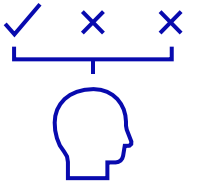
Stress testing

- Understand the convexity risk associated with dynamic lapse behavior through stress testing approach

04

Hedges

- Implement a hedging strategy to manage and mitigate the risk of loss under a sharp interest rate increase

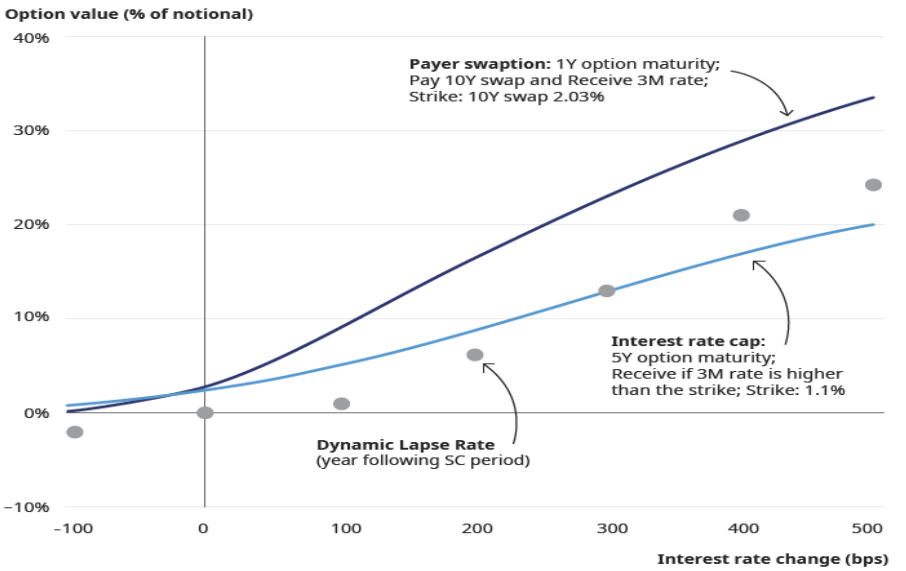


HEDGES AGAINST RISK ASSOCIATED DYNAMIC LAPSE

Interest rate derivatives

- Interest rate caps and payer swaptions can be effective hedging instruments to mitigate the dynamic lapse risk under rising interest rate scenarios
- Their market value sensitivities relative to interest rate changes would somewhat mimic the liability dynamic lapse impact such that 1) market value increases under rising interest rates 2) there is positive convexity and 3) the downside risk is floored with the initial option cost if interest rate declines

Value sensitivities of interest rate derivatives [1]



Derivatives	Description
Interest rate cap	• The derivatives holders receive payments if the short-term interest rate (e.g., LIBOR) exceeds the strike price • Interest rate cap has negative duration but positive convexity • The instrument can provide more flexibility to adjust overall duration and convexity
Payer swaption	• The option holders retain an option to enter into a swap when the reference rate (fixed paying leg, e.g., 10Y swap rate) is lower than the market interest rate • The payer swaption holders get the benefit when the long-term swap rate (e.g., 10Y tenor) increases (i.e., similar to interest rate cap, but the reference rate ties to a long-term rate)

Note(s) [1] Bloomberg data as of 3/31/2021

CASE STUDY: CONVEXITY IMPACT ON STRESS TESTING APPROACH

Background

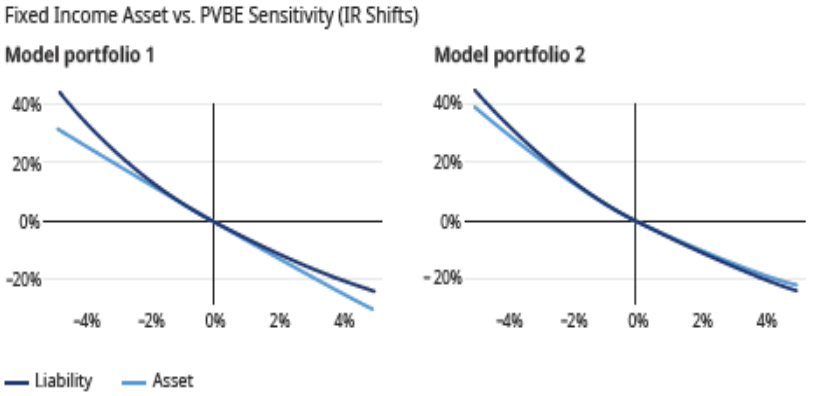
Stress testing analysis for varying convexity matching profiles
Illustrative case study

Liability profile: Fixed indexed annuities (with multi-year guarantees).
Asset Portfolio: Two illustrative model portfolios with similar yield/duration but different convexity profile.

	Duration	Convexity
Liabilities	6.1	0.77 (Static convexity)
Model portfolio 1	6.1	0.14
Model portfolio 2	6.1	0.70

Asset value vs. liability value with static convexity

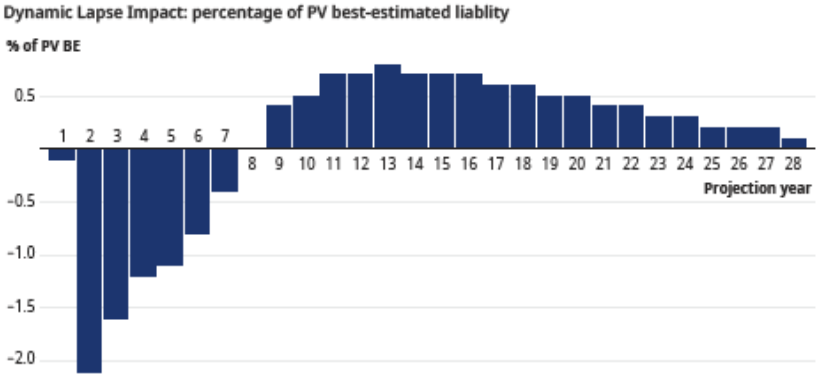
Economic value analysis: ALM sensitivities against interest rate changes



Interest rate derivatives

- Payer swaption is considered
  - 1Y option maturity
  - Pay 10Y swap and Receive 3M rate
  - Strike: 10Y swap 2.03%
  - Option premium: 3.0% per notional amount

Dynamic lapse impact



CASE STUDY: RISK ANALYSIS AND HEDGE IMPACT

Risk analysis when IR changes by +300bps

01	• Both portfolios match the liability duration well, resulting in net neutral position under rising interest environment
02	• Model portfolio 1 would incur a large amount of economic loss as the static convexity of liability is larger than the asset convexity
03	• Both portfolios would incur an economic loss due to the increasing dynamic lapse under rising interest rate scenario
04	• The resulting economic value of Model Portfolio 1 would decline by 2.5% more than Model portfolio 2 which had better convexity matching
05	• Based on the option valuation sensitivities, the required hedge notional amount (a payer swaption) to offset the losses from the dynamic lapse under the IR +300bps stress scenario is about 10% of the reserve amount (cost is about 30bps with 6.8x benefit-to-cost multiple under the IR +300bps scenario) • The excess liability cash flow, when the interest rate starts to increase more than 100bps, would be well covered by the interest rate derivatives
06	• Model portfolio 2 illustrates that most of interest rate risk under short-term interest rate spikes can be mitigated with better convexity matching and use of derivatives

		Model portfolio 1			Model portfolio 2		
		Asset	**Liability**	**Net**	**Asset**	**Liability**	**Net**
1	IR Duration	-18.39%	18.39%	0.00%	-18.39%	18.39%	0.00%
2	Convexity	0.63%	-3.48%	-2.85%	3.14%	-3.48%	-0.34%
3	Dynamic Lapse	0.00%	-1.56%	-1.56%	0.00%	-1.56%	-1.56%
4	**Surplus change (pre-tax, before hedges)**	**-17.76%**	**13.35%**	**-4.42%**	**-15.25%**	**13.35%**	**-1.90%**
5	Hedges (a payer swaption)	2.04%	0.00%	2.04%	2.04%	0.00%	2.04%
6	**Surplus change (net of hedges)**	**-15.72%**	**13.35%**	**-2.38%**	**-13.21%**	**13.35%**	**0.14%**

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