Liquidity Risk in Insurance and Macroprudential Regulation

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Background

- Focus today: Financial guarantees embedded in variable annuities contracts in the US
  - *Insurers as Asset Managers and Systemic Risk*, Andrew Ellul, Chotibhak Jotikasthira, Anastasia Kartasheva, Christian T Lundblad, Wolf Wagner, The Review of Financial Studies, Volume 35, Issue 12, December 2022, Pages 5483–5534, https://doi.org/10.1093/rfs/hhac056
- Explicit or implicit financial guarantees exists in other settings in the insurance industry
  - The UK pension crisis in 2022: Margin calls on interest rate swaps due to rates surge prompt forced fire sales (Jensen et al., 2024)
  - Covid 19 crisis and Collateral Loan Obligations (CLO) investment of the US life insurers: CLO became information sensitive during the crisis which led to mass redemptions and distress of MMMFs (Foley-Fischer et al., 2024)

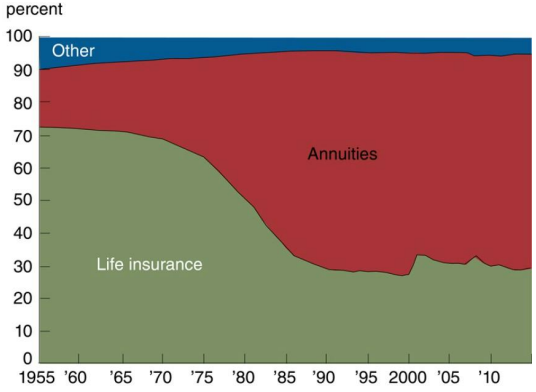
Research Motivation I

- Systemic risk can arise from interconnectedness of institutions
  - Lots of evidence of the impact from interconnectedness on the liability/funding side (mostly from banking literature)
  - Scarce evidence on impacts of interconnectedness arising from the asset side
    - Acharya and Yorulmazer (2007, 2008): "Too many to fail" guarantees leading to herding
    - Greenwood et al. (2015): Fire sales spreading contagion across banks holding the same assets

- **This paper:** Proposes a new mechanism through which financial institutions' off-balance sheet commitments induce
  - Reaching for yield (RFY)
  - Asset interconnectedness leading to potential systemic risk
- New mechanism: shared business model

Research Motivation II

- **Our laboratory: U.S. life insurers writing Variable Annuities (VAs)** = similar to asset managers



Sources: American Council of Life Insurers, *2015 Life Insurers Fact Book*, and authors' calculations.

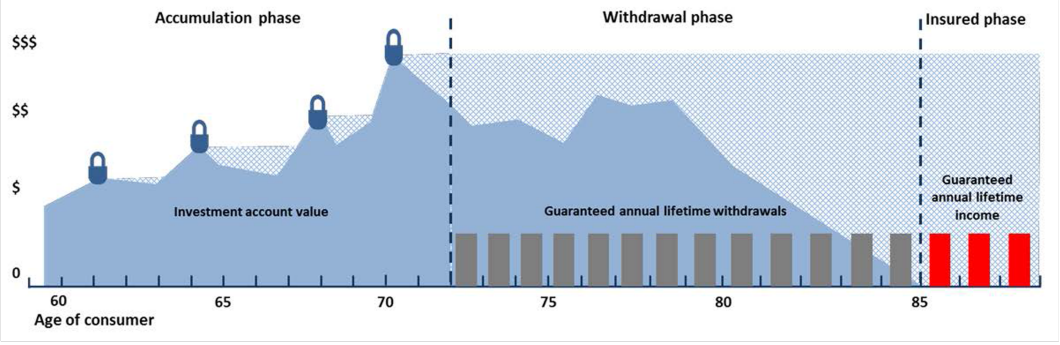
- VAs embed guarantees, exposing insurers to common, undiversifiable shocks
- Guarantees are common for a host of financial institutions, e.g. Defined Benefit pension plans, banks' securitization arrangements

Variable Annuities

- **A Variable Annuity** is a long-term retirement saving contract between an insurer and a policyholder
  - The fund is invested in stocks ($> 70\%$), bonds, and money markets
- An insurer allocates policyholder savings to a separate account and acts as a delegated asset manager of policyholder's funds
- **To compete with other savings alternatives**, insurers offer a host of guarantees
  - An assurance that the policyholder's savings and annuity payments are protected from adverse market conditions, e.g., Guaranteed minimum income benefit

Variable Annuities

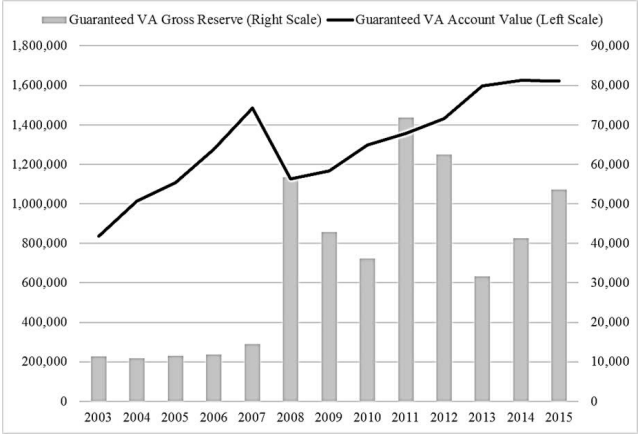
A Variable Annuity with a guarantee is a (complicated) put option where the strike price is not set once but several times



Variable Annuity Payout Pattern with Guaranteed Lifetime Withdraw Benefit (GLWB). *Source: Government Accountability Office (GAO) Reports: Retirement Security, December 2012.*

Guarantees and Insurer's Capital

- **Guarantees** = **Put options**. Insurers are required to hold:
  - Statutory reserve to ensure promised payments
  - Plus, additional Risk-Based Capital (RBC) to absorb extreme losses
- Both reserves and RBC spike during stress periods



Our Thesis: Guarantee → Systemic Risk?

- Traditional life policies expose insurers to "diversifiable" risk, while VAs expose them to "systematic" risk
  - Factors that influence VA-related reserves: stock prices and interest rates
- To mitigate risk, insurers hedge their market exposures
- Impact from guarantee writing on illiquid bond holdings:
  - Profits from guarantees alleviate the regulatory constraint... more RFY
  - Guarantees come with relatively higher capital requirements... less RFY
- First effect likely to dominate when hedging effectiveness (operating through lower capital requirements) is considered
- Insurers become interconnected on the asset side, and in case of shocks, they will engage in fire sales of illiquid bonds to re-gain financial health

Framework of Analysis

- **Step I:** Model to analyze the mechanism through which VAs with guarantees:
  - Engender correlated investment decisions across life insurers during non-stress periods
  - Propagate correlated liquidation during stress periods to meet the funding requirements on reserves

- **Step II:** Calibrate the model to U.S. life insurance data and obtain estimates of correlated investments in:
  - Liquid bonds
  - Illiquid bonds
  - Equity and price impacts due to liquidation during distress periods (fire sales and contagion)

Model: Major Challenges

- Guarantee writing is an endogenous choice
  - "Abolishing guarantees" may result in an insurer taking on risk along other dimensions
  - Same applies to the hedging choice
- Guarantee-writing likely to be correlated with other insurer characteristics (i.e., "sophistication")
  - Need to disentangle these effects
- Unwinding the guarantees has systemic fire-sale effects ("general equilibrium" effects)

Model: Key Elements

- An insurer with total assets $A =$ equity $E +$ liabilities D
- Chooses portfolio allocation to maximize expected return

- Insurer decides upon share $\tilde{g}$ of VAs with guarantees
  - Traditional (life insurance) business generates constant unit profit
  - Guarantee writing exhibits declining returns

- Three assets: Liquid bond (L), Illiquid bond (I), and Stock (S) with returns $r_S > r_I > 0 = r_L$

- Insurer prefers a stock-bond allocation of $\bar{\alpha}_S(\eta)$ depending on level of sophistication η

Model: Hedging

- Insurer hedges a fraction $h \in [0, 1]$ of the guarantees using dynamic hedging
  - Shorting the stock market and going long bonds
  - An amount of $h|\delta|\tilde{g}\frac{D}{A}$ in the stock market, where δ denotes the "generosity" of the guarantee, and long on bonds
- Hedging exhibits declining returns and is encouraged by the regulatory capital relief
  - Hedging effectiveness decreases in η
  - Benefit: Lower regulatory capital requirements, but relief is capped by regulators at κ
  - Cost: Lower portfolio returns

Insurers' Optimization

- Insurer maximizes profits from underwriting premiums (life + VAs) and returns from assets held
- Insurer chooses guarantees $\tilde{g}$, hedging h, and portfolio weights α_S, α_I, α_L
- Insurer faces regulatory capital constraint with risk weights γ_i

$$\frac{E}{\left(\bar{\alpha}_s\gamma_S + \alpha_I\gamma_I + \left(1 - h\left(1 - \frac{\eta h}{2}\right)\kappa\right)\widetilde{g}\frac{D}{A}\gamma_G + (1-\widetilde{g})\frac{D}{A}\gamma_T\right)A} \geq \rho$$

VAs and Reaching for Yield

- Profits from guarantees alleviate the regulatory constraint and allow insurers to hold more illiquid bonds
- Guarantees come with relatively higher capital requirements,compared to traditional life insurance

$$\left(e_G - \frac{f}{2}\widetilde{g}^* - e_T\right) > \rho\left[\left(1 - \widetilde{h}^*\right)\gamma_G - \gamma_T\right]$$

- The effect can, in principle, go either way, but ...
- ... the net effect depends on the extent to which hedging is effective

Main Prediction

- Case of "complete" hedging: The first effect dominates (i.e., new funds to reach for yield), and guarantee writing unambiguously leads to more holdings of illiquid bonds
- Main Conclusion: Writing guarantees increases holdings of illiquid bonds iff guarantees are sufficiently profitable relative to their required capital

Insurer-level Data

- NAIC data obtained through SNL Financial
- 176 Life insurers (groups and stand-alone insurers) in 2010-2015
  - Insurers with (guaranteed) VAs, 82 entities
  - Insurers without VAs with assets $\geq$ 5th PCT of Insurers with VAs
- VA information: account values, gross reserves, reinsurance credits
  - Delta inferred by picking put option strike that matches the gross reserve
- Schedule D for portfolio year-end positions (corporate bonds, ABSs, mortgages, etc.), and trading activities
- Schedule DB for derivative positions

Model Predictions and Calibration

- More guarantee hedging = Less net stock holding

$$\alpha_s = \bar{\alpha}_s - h|\delta|\widetilde{g}\frac{D}{A}$$

- Allows "sophistication" (proportional to ln(Assets)) to affect stock holding both **directly** and through **guarantee hedging:**

$$\textbf{(1) } \ldots \quad \alpha_S = \bar{\alpha}_{S0} + \bar{\alpha}_{S1}\eta_X \left(\frac{1}{1+\ln(\text{Assets})}\right) - \frac{1}{\eta_X}\left(\frac{(1-h_0|\delta|)|\delta|\widetilde{g}\frac{D}{A}}{1+\ln(\text{Assets})}\right)$$

- More VA (with guarantee) = More profit/capital for RFY

$$\textbf{(2) } \ldots \quad \frac{\text{Underwriting Profit}}{\text{Total Reserve}} = e_T \cdot \frac{D}{A} + (e_G - e_T)\cdot\widetilde{g}\frac{D}{A} - \frac{f}{2}\cdot\widetilde{g}^2\frac{D}{A}$$

But marginal profit declines as VA increases

Overview of Empirical Analysis

- **Portfolio allocation:** The higher the amount of guarantee and hedging, the higher the amount of capital available for RFY
  - Different types of illiquid bonds for RFY:
  - Junk Bonds, Private label ABS classified as Class 1 (higher than BBB), Class 2 (BBB), and Class 3 (lower than BBB), Mortgage loans, Other bond-like assets (private equity, etc.)

- **Fire sales induced by herding:** Following a shock, insurers need to liquidate assets to fulfill the capital requirement
  - Shock to stock market, shock to illiquid bonds, shock to guarantee value, and categorical shocks
  - Adverse (10th percentile) and severely adverse (worst) scenarios.

Preliminary Evidence - I

- **Higher VA exposures = Less liquid bond allocation**
- Relationship is monotonic (difference between [1] and [4] is over 13%) but partially offset by synthetic cash from hedging the VAs

	Mean				Difference		
Category	[1] High	[2] Medium	[3] Low	[4] No Guarantee	[1] - [2]	[1] - [3]	[1] - [4]
Gross reserve to capital (%)	41.795	2.933	0.044	0.000	38.862***	41.751***	41.795***
Liquid bonds	0.648	0.644	0.676	0.742	0.003	-0.029	-0.094***
Excluding synthetic cash from hedge	0.604	0.631	0.675	0.741	-0.026***	-0.070***	-0.137***
Cash	0.030	0.027	0.019	0.046	0.003	0.011***	-0.016*
Synthetic cash	0.043	0.014	0.002	0.000	0.029***	0.042***	0.043***
Bonds in NAIC 1	0.293	0.261	0.304	0.348	0.032	-0.010	-0.055*
Bonds in NAIC 2	0.228	0.264	0.289	0.249	-0.037	-0.022	-0.021
Agency ABS in NAIC 1	0.053	0.078	0.103	0.098	-0.025*	-0.049***	-0.045***
Agency ABS in NAIC 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000*

Preliminary Evidence - II

- Insurers with high VA exposures have a significantly higher allocation to illiquid bonds than do insurers with lower (by 3-6%) or no VA exposures (by almost 15%)

	Mean				Difference		
Category	[1] High	[2] Medium	[3] Low	[4] No Guarantee	[1] - [2]	[1] - [3]	[1] - [4]
Illiquid bonds	0.339	0.308	0.278	0.192	0.030*	0.060**	0.146***
Long-term assets	0.029	0.028	0.023	0.014	0.001	0.006	0.015***
Bonds in NAIC 3-6	0.030	0.035	0.031	0.030	-0.005	-0.001	-0.001
Agency ABS in NAIC 3-6	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Private-label ABS in NAIC 1	0.098	0.095	0.096	0.072	0.003	0.002	0.026*
Private-label ABS in NAIC 2	0.010	0.011	0.012	0.007	-0.001	-0.001	0.003**
Private-label ABS in NAIC 3-6	0.011	0.008	0.006	0.005	0.003*	0.004***	0.006***
Mortgages	0.101	0.081	0.073	0.040	0.020	0.028*	0.061***
Loans	0.044	0.044	0.032	0.022	0.000	0.012	0.022**
Derivatives for income generation	0.016	0.006	0.005	0.001	0.009**	0.011**	0.014**
Common stock exposures	-0.007	0.035	0.035	0.047	-0.042***	-0.041***	-0.053***

Model Predictions and Calibration

- More guarantee hedging = Less net stock holding

$$\alpha_s = \bar{\alpha}_s - h|\delta|\widetilde{g}\frac{D}{A}$$

- Allows "sophistication" (proportional to ln(Assets)) to affect stock holding both **directly** and through **guarantee hedging:**

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But marginal profit declines as VA increases

VAs Hedging and Stock Allocation

- Hedging 100% would further **decrease the net stock allocation by 1-11%** (mean = 3%) for the high VA group
- **Implied hedge ratios = 42-96%** (mean = 60%). (Additional puts about 5%)

Dependent Variable	Stock/Assets
1/(1 + ln(Assets))	0.336
	(0.174)
VA hedging term	-0.238
	(0.129)
RBC ratio	0.001
	(0.000)
Year fixed effects	YES
Observations	357
R-squared	0.044

- **Implied** $\bar{\alpha}_{S1} = 0.080$, which means that even without the VA, the most sophisticated insurer would still invest about 7% less in stocks than the least sophisticated
- **Implied** $\eta_X = 4.202$, which means η ranges from 0.302 (most sophisticated) to 1.258 (least sophisticated)

VAs and Underwriting Profits

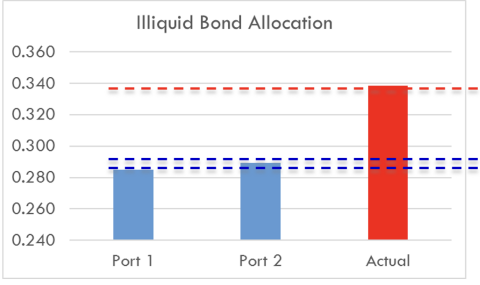
- Without hedging, optimal VA is about 13% of total reserves
- Hedging permits capital relief, thus increasing the optimal level. Only some very large insurers, however, write more VAs than the implied optimal

Dependent Variable	Net Premium/Reserves
VA term	1.507
	(0.375)
VA squared term	-5.011
	(1.491)
RBC ratio	-0.000
	(0.003)
Year fixed effects	YES
Observations	325
R-squared	0.043

- **Implied** $e_G - e_T = 1.507$, which means that the first dollar of VA written increases net premium by over 170% (given the net premium per one dollar of traditional business of 21%)
- **Implied** $f = 10.022$, which implies that VA profits shrink quickly

Counterfactual Portfolios

- Portfolio allocation is driven by two factors:
  - **Guarantee & hedging**: Tilt the allocation towards bonds
  - **RFY**: Tilt the bond allocation to illiquid (riskier) bonds
- Using parameter estimates, we can create counterfactuals:
  - **Hypothetical Portfolio 1**: What if no VA?
  - **Hypothetical Portfolio 2**: What if actual VA and hedging but no RFY?



Guarantees and Systemic Risk

- With some probability, a common shock may hit
- What is the impact of a shock on fire sales, and how much is attributed to VAs?
  - Stock market shock, and shock to illiquid bonds
  - Shock to the guarantee, e.g., increase in stock market volatility
  - Categorical asset shock = all three
- **A shock reduces capital** by lowering asset values and increasing the guarantee liability
  - "De-risk" by selling illiquid bonds (keep stocks at target level)
  - Illiquid bonds are sold at a discount that increases proportionally with the amount sold by the whole market

Adverse Shocks (Bottom 10th pct)

- **Without VAs**, even categorical shocks would result in **the fire-sale costs of just 7% of insurers' capital**
- **VAs** would more than double the fire-sale amount, increasing **the fire-sale costs to the max of 36% of capital**
  - Stock exposure itself is relatively unimportant. Major factor is RFY

Fire-Sale Amount ($ Million)

		Net Increase			Decomposition		
Type of Shock	Magnitude of Shock	Actual	No VA	from VA	VA Exposure	Hedging	RFY
Stock	19%	143,950	78,719	65,231	36,039	-18,765	47,958
Illiquid bond	5%	424,236	197,571	226,665	-6,222	1,995	230,893
Guarantee	30%	241,756	0	241,756	160,519	696	80,542
Categorical (All Above)	All Above	615,153*	276,290	338,863*	152,749*	3,036*	183,078*

Fire-Sale Cost ($ Million)

		Net Increase			Decomposition		
Type of Shock	Magnitude of Shock	Actual	No VA	from VA	VA Exposure	Hedging	RFY
Stock	19%	3,854	1,153	2,702	1,297	-736	2,140
Illiquid bond	5%	33,476	7,260	26,215	-450	143	26,523
Guarantee	30%	10,871	0	10,871	-4,793	42	6,037
Categorical (All Above)	All Above	70,385*	14,199	56,186*	20,039*	486*	35,661*

Severely Adverse Shocks (Worst)

- **Without VAs**, except the case where all worst shocks hit at once, the fire-sale amount is limited and **the fire-sale costs are less than 10% of capital**
- **With VAs**, even individual (e.g., illiquid bond) shock could lead to the maximum fire sales (all illiquid bonds), with **the fire-sale costs of 36% of capital**
  - Stock exposure itself is relatively unimportant. Major factor is RFY

Fire-Sale Amount ($ Million)

		Net Increase			Decomposition		
Type of Shock	Magnitude of Shock	Actual	No VA	from VA	VA Exposure	Hedging	RFY
Stock	48%	363,664	198,869	164,795	91,047	-47,407	121,156
Illiquid bond	8%	615,153*	316,113	299,040*	-9,956	3,191*	305,804*
Guarantee	100%	615,153*	0	615,153*	429,039*	3,036*	183,078*
Categorical (All Above)	All Above	615,153*	429,039*	186,114*	0*	3,036*	183,078*

Fire-Sale Cost ($ Million)

		Net Increase			Decomposition		
Type of Shock	Magnitude of Shock	Actual	No VA	from VA	VA Exposure	Hedging	RFY
Stock	48%	24,599	7,356	17,243	8,277	-4,695	13,660
Illiquid bond	8%	70,385*	18,587	51,798*	-1,152	365*	52,585*
Guarantee	100%	70,385*	0	70,385*	34,238*	486*	35,661*
Categorical (All Above)	All Above	70,385*	34,238*	36,147*	0*	486*	35,661*

Conclusions

- How systemic risk may arise from the inter-connectedness of the asset side of financial institutions' balance sheets?
- Propose an innovative mechanism: an incentive that arises from the financial institutions' business model
- Herding in illiquid assets emerges in equilibrium, increasing the likelihood of fire sales in the event of common shocks
- Our paper: the transformation of the life insurance industry has made these institutions less likely to behave as asset insulators
- More importantly, they are now more likely to contribute to systemic risk through correlated regulatory-induced fire-sales

References

- *Insurers as Asset Managers and Systemic Risk*, Andrew Ellul, Chotibhak Jotikasthira, Anastasia Kartasheva, Christian T Lundblad, Wolf Wagner, The Review of Financial Studies, Volume 35, Issue 12, December 2022, Pages 5483–5534, https://doi.org/10.1093/rfs/hhac056
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