Insurers as Asset Managers and Systemic Risk

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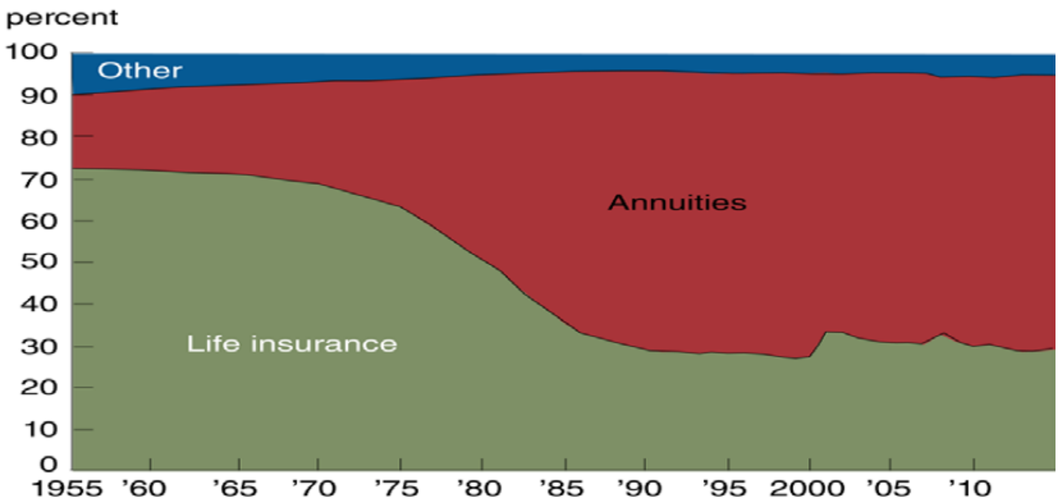
Research Motivation I

- **Systemic risk can arise from the interconnectedness** of institutions.
  - Substantial evidence on the liability/funding side (mostly from banking)
  - Small, but growing evidence on **the asset side.**
    - Acharya and Yorulmazer (2007, 2008): "Too many to fail" guarantees leading to herding in asset holdings.
    - Greenwood et al. (2015): Fire sales can create contagion spreading across banks holding the same assets.

- **This paper**: Proposes a **new mechanism** through which financial institutions' business commitments induce (a) reaching for yield, and (b) asset interconnectedness, leading to systemic risk.
  - New mechanism: **Shared business model.**

Research Motivation II

- **<u>Our laboratory</u>: U.S. life insurers writing Variable Annuities (VAs)** = Asset managers but with caveats.



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

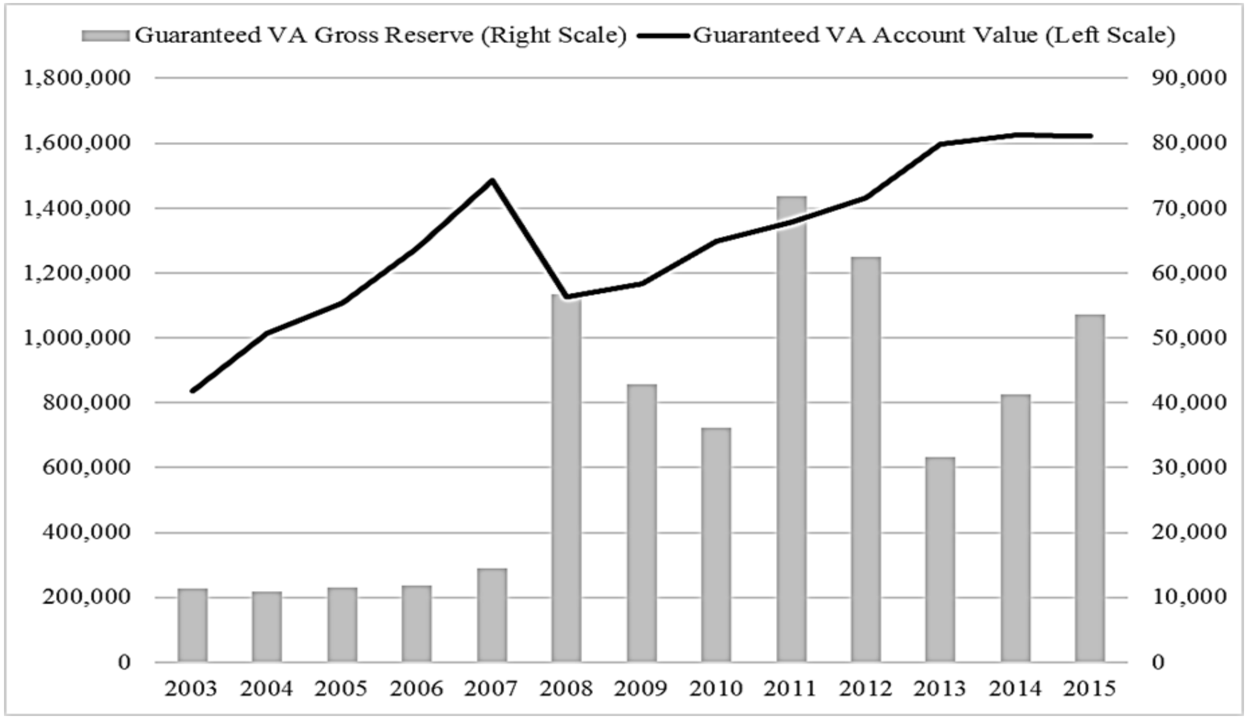
- VAs embed **guarantees**, exposing insurers to **common, undiversifiable shocks**. Hedging the guarantees leads to **correlated asset portfolios**.
- Guarantees are common for financial institutions, e.g. Defined Benefit pension plans, Banks' securitization arrangements.

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.
  - Just like mutual funds, policyholder bears the market risk.
- **To reduce market risk** and compete with other savings alternatives, insurers offer **a host of guarantees**.
  - An assurance the policyholder's savings and annuity payments are protected from adverse market conditions, e.g. Guaranteed minimum income benefit.

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 <u>spike during stress periods</u>.



Our Thesis: Guarantee → Systemic Risk?

- Traditional life policies expose insurers to "diversifiable" risk, while VAs expose them to "systematic" risk.
  - The two most important factors that influence VA-related reserves are **stock prices (and volatilities)** and **interest rates.**
- To mitigate the risk and to avoid having to raise capital during market downturn, insurers **hedge their market exposures** using both comprehensive hedging (options) and **delta hedging programs**.
- However, hedging is costly. Insurers **only partially hedge** and engage in "**reaching for yield**" to offset the hedging costs and make up the increase in reserve.
  - Reaching for yield often involve **illiquid assets**, which may propagate shocks across the financial system through **fire sales**.

Framework of Analysis

- Build a model to analyze our hypothesized mechanism through which VAs with guarantees give rise to systemic risk:
  - Hedging engenders **correlated investment decisions** across life insurers during normal periods.
  - Asset shocks induce **correlated liquidation** during stress periods to meet regulatory reserve/capital requirements.

- Calibrate the model to U.S. life insurance data and obtain estimates of **VA-induced correlated investments** in (a) liquid bonds, (b) illiquid bonds, and (c) equity, and **price impacts** due to correlated liquidation during distress periods.
  - Fire sales may erase up to **20-70% of insurers' capital**.

Key Elements of the Model

- A risk neutral insurer with total assets A and equity capital E.
  - Chooses portfolio to maximize expected return.
  - Three assets: Liquid bond (L), Illiquid bond (I), and Stock (S) with returns $r_L = 0 < r_I < r_S$
  - Portfolio weights denoted by $(\alpha_L, \alpha_I, \alpha_S)$.

- Two constraints:
  - Hedging: Insurer hedges a fraction h of its effective stock market exposures, induced by the guarantee → **Overweight bonds/Underweight stocks.**
  - Capital: Insurer faces risk-based capital requirement, and must keep its RBC ratio of at least ρ. → **Tilt towards illiquid bonds as permitted by capital.**

Hedging and Capital Constraints

- Insurer writes a total amount of guarantee: gA. The underlying asset is stock (77% of VAs in reality).
- Generosity of guarantee: When stock goes down by 1 unit, the value of guarantee increases by $|\delta|gA$.

→ **Hedging:** $\boldsymbol{\alpha_L + \alpha_I \geq h \cdot |\delta| g}$

- Insurer faces fair capital charges (risk weights) $(\gamma_L, \gamma_I, \gamma_S)$ that ignore illiquidity costs: $\frac{\gamma_I}{r_I} = \frac{\gamma_S}{r_S}$ and $\gamma_L = 0$

→ **Capital:** $\boldsymbol{\frac{E}{(\alpha_I \gamma_I + \alpha_S \gamma_S)} \geq \rho}$

Optimal Portfolio Choice

- Under certain assumptions, both constraints are binding:
  - Insurer has to invest in **bonds** at least: $\boldsymbol{\alpha_L + \alpha_I \geq h \cdot |\delta| g}$
  - The remainder is invested in stocks: $\boldsymbol{\alpha_S^* = 1 - h \cdot |\delta| g}$
  - Within bonds, insurer **over-weights the illiquid bond**:

$$\boldsymbol{\alpha_I^* = \left[\frac{E}{\rho A} - (1 - h \cdot |\delta| g)\gamma_S\right]\frac{1}{\gamma_I}}$$

- Larger guarantee exposure $|\delta|g$ will lead to smaller holding of stock α_S^* and larger holding of illiquid bond α_I^*:

$$\boldsymbol{\frac{\partial \alpha_S}{\partial |\delta| g} = -h < 0} \quad \text{and} \quad \boldsymbol{\frac{\partial \alpha_I}{\partial |\delta| g} = h\frac{\gamma_S}{\gamma_I} > 0}$$

Data

- NAIC data obtained through SNL Financial.
- 176 Life insurers (groups and stand-alone insurers) over the period 2004-2013.
  - Insurers with VA guarantees: 82 entities
  - Matching insurers without VAs, with asset size of at least the 5th percentile of insurers with VA.

- VA information: Account values, Gross reserves, Reinsurance credits
- NAIC Schedule D: Portfolio year-end positions (corporate bonds, ABSs, mortgages, etc.)
- NAIC Schedule DB: Derivatives positions.

Insurers' Characteristics

- Insurers with high VA exposures are generally larger than others both in terms of assets (in the general account or on balance sheet) as well as capital and surplus
- Insurers with no VAs are the smallest, despite our attempt to match by asset size.

	[1] High			[2] Low			[3] No Guarantee			[1] - [2]	[1] - [3]
	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Mean
Panel A: Firm Characteristics											
Assets ($ Million)	54,452	66,070	32,894	32,099	50,509	11,027	5,404	11,198	1,702	22,353*	49,047***
Capital and surplus ($ Million)	4,959	5,827	3,048	3,596	5,721	1,225	712	1,208	244	1,363	4,247***
RBC ratio	9.395	4.945	8.760	10.335	4.605	9.142	10.944	11.248	8.691	-0.940	-1.549
Return on equity	0.065	0.167	0.087	0.074	0.082	0.078	0.069	0.171	0.070	-0.008	-0.003
Stock return	0.116	0.372	0.125	0.127	0.283	0.109	0.120	0.304	0.114	-0.011	-0.003

Preliminary Evidence I

- **Both groups of insurers that write VAs** have **significantly lower liquid bond allocations (about 8%)** than insurers with no VAs.
- The differences are driven by **Bonds and Agency ABS in NAIC class 1** but are partially offset by synthetic cash from selling stock futures.

	[1] High			[2] Low			[3] No Guarantee			[1] - [2]	[1] - [3]
	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Mean
Panel B: Asset Allocation											
Liquid bonds	0.653	0.115	0.634	0.657	0.135	0.655	0.737	0.138	0.753	-0.004	-0.084***
Cash	0.035	0.036	0.025	0.024	0.025	0.018	0.050	0.081	0.028	0.010***	-0.015**
Synthetic cash	0.032	0.048	0.003	0.006	0.027	0.000	0.000	0.000	0.000	0.025***	0.032***
Bonds in NAIC 1	0.297	0.127	0.274	0.282	0.204	0.279	0.350	0.261	0.378	0.015	-0.053*
Bonds in NAIC 2	0.208	0.064	0.212	0.228	0.111	0.207	0.205	0.139	0.193	-0.020	0.003
Agency ABS in NAIC 1	0.081	0.066	0.066	0.116	0.086	0.106	0.131	0.129	0.104	-0.035**	-0.050***
Agency ABS in NAIC 2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Preliminary Evidence II

- Insurers with **<u>high VA exposures have</u>** **a significantly higher allocation to illiquid bonds** and **a significantly lower allocation to stocks** than do both insurers with low or no VA exposures
- Summary statistics for the asset allocations are generally consistent with our model's predictions

	[1] High			[2] Low			[3] No Guarantee			[1] - [2]	[1] - [3]
	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Std. Dev.	Median	Mean	Mean
Illiquid bonds	0.326	0.113	0.347	0.288	0.120	0.289	0.195	0.126	0.178	0.038*	0.131***
Long-term assets	0.024	0.021	0.020	0.021	0.022	0.012	0.012	0.018	0.004	0.003	0.013***
Bonds in NAIC 3-6	0.034	0.018	0.032	0.032	0.020	0.032	0.028	0.032	0.019	0.002	0.006
Agency ABS in NAIC 3-6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Private ABS in NAIC 1	0.108	0.060	0.106	0.104	0.083	0.096	0.078	0.090	0.045	0.004	0.031***
Private ABS in NAIC 2	0.011	0.011	0.009	0.008	0.012	0.004	0.007	0.012	0.002	0.002	0.004***
Private ABS in NAIC 3-6	0.008	0.008	0.006	0.005	0.006	0.003	0.004	0.008	0.001	0.003***	0.004***
Mortgages	0.087	0.062	0.097	0.077	0.059	0.087	0.041	0.065	0.005	0.010	0.046***
Loans	0.045	0.047	0.030	0.036	0.031	0.024	0.025	0.031	0.014	0.009	0.021**
Derivatives for income gen.	0.008	0.013	0.003	0.005	0.010	0.000	0.001	0.003	0.000	0.004*	0.008***
Common stock exposures	0.000	0.051	0.010	0.041	0.058	0.026	0.046	0.063	0.021	-0.040***	-0.045***

Inferring Effective Guarantee Exposures

- Our goal is to estimate the sensitivity of portfolio allocation to guarantee exposure $|\delta|g$ (which is a function of the hedge ratio in our model).
- But, we do not observe $|\delta|g$, only g and its associated reserve.
- Assuming that change in reserve is $-r_S \cdot |\delta|g$, we can use **the law of motion** to infer $|\delta|g$.

$$\frac{reserve_t}{value_t} = \frac{reserve_{t-1} + \boxed{\delta_{t-1} \cdot value_{t-1}} \cdot ret_{stock,t-1,t} + newreserve_t}{value_{t-1} \cdot (1 + ret_{t-1,t}) + newvalue_t}$$

- We also assume that (i) 77% of account value as stocks as an underlying (23% money markets), and (ii) reserve generosity is about the same over time.

Guarantees and Portfolio Allocation

- A one standard deviation increase in normalized delta is associated with an **increase in illiquid bond allocation of 9%**, decrease in liquid bond allocation of 5.6%, and **decrease of common stock allocation of 3.3%.**

Panel A: Equation by Equation OLS

	Asset Allocations			
	Liquid Bonds (1)	Illiquid Bonds (2)	Common Stocks (3)	Others (4)
Delta/Assets	-1.194***	1.857***	-0.667***	
	(0.349)	(0.340)	(0.221)	
RBC ratio	0.003***	-0.002***	-0.000	-0.000**
	(0.001)	(0.001)	(0.000)	(0.000)
Year fixed effects	YES	YES	YES	YES
Observations	1,071	1,071	1,071	1,071
R-squared	0.038	0.043	0.018	0.057

Implied delta hedge ratio

Implied Hedging and Capital Constraints

- Insurers hedge overall about 75% of their guarantee exposure, of which **70% is delta hedging** and **5% is in the form of options**
- Given a capital requirement of 0.30 for common stock, the estimated capital requirement for illiquid bonds is 11.3%

	Data			Estimation		
	Mean	Std. Dev.	Median	Mean	PCT5	PCT95
Comprehensive hedging - effective	0.000	0.000	0.000	-	-	-
Comprehensive hedging - others	0.052	0.121	0.000	-	-	-
Delta hedging	-	-	-	0.690	0.658	0.721
RBC requirement for illiquid bonds	0.060	0.020	0.058	0.113	0.049	0.177

Test of over-identifying restrictions

Counterfactual Portfolios

- Portfolio allocation is driven by two factors
  - Hedging of guarantee exposure: tilt the allocation to bonds
  - Reaching for yield: tilt the bond allocation to illiquid (riskier) bonds

- **Hypothetical Portfolio 1**: Actual – Port 1 = "reaching for yield"
  - Keep total bond allocation the same as actual (= same VA exposure and same hedge ratio), but
  - "Re-allocate between" liquid and illiquid bonds such that the ratio of their allocations is as if the insurer had no VAs.

- **Hypothetical Portfolio 2**: Port 1 – Port 2 = "partially exposure to guarantees"
  - Set the normalized delta to zero (= no VA exposure and no hedging).

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, proportional reduction in values of all assets.

- **A shock reduces capital** by lowering asset values and increasing the guarantee liability.
  - Deleverage by selling assets proportionally (as in Greenwood et al. 2015).
  - Stocks and liquid bonds are sold at fair value; illiquid bonds face a discount of $c_0 S$, where S is the total sales of illiquid bonds by all insurers.

Equilibrium Level of Fire Sales

- From the capital requirement constraint, derive the amount of sales by an individual insurer:

$$s = (\varepsilon + \alpha_I \cdot c_0 S)\frac{A - E}{E}.$$

Shock as fraction of A

- With a collection of insurers, each denoted by *i*, total equilibrium sales are as follows:

$$S = \frac{\varepsilon \sum_i \frac{A^i - E^i}{E^i} \alpha_I^i A^i}{1 - c_0 \cdot \sum_i \alpha_I^i \frac{A^i - E^i}{E^i} \alpha_I^i A^i}.$$

- We measure <u>total fire sale costs</u>, **our measure of systemic risk**, as

$$C = S \cdot c_0 S$$

Stock Market Shock

- Stock market shocks 10-40% → insurers selling $114-458 billion of illiquid bonds → fire-sale costs = $2-39 billion = 1-21% of insurers' total capital
- Without VAs, the sale amount =$50-201 billion → fire-sale costs = $0.5-7.5 billion

Magnitude of Shock	Fire-Sale Amount ($ Million): Actual Portfolio + VAs	Portfolio 1 + Actual VAs	Portfolio 2 + Actual VAs	Portfolio 2 + No VAs	Decomposition of Fire-Sale Amount ($ Million): Reaching for Yield	Hedging Guarantee Exposure	Gross Guarantee Exposure
10%	114,387	63,792	96,153	50,343	50,595	-32,361	45,810
20%	228,775	127,584	192,306	100,685	101,191	-64,722	91,620
30%	343,162	191,376	288,459	151,028	151,786	-97,083	137,431
40%	457,549	255,168	384,611	201,370	202,382	-129,444	183,241

Magnitude of Shock	Fire-Sale Costs ($ Million): Actual Portfolio + VAs	Portfolio 1 + Actual VAs	Portfolio 2 + Actual VAs	Portfolio 2 + No VAs	Decomposition of Fire-Sale Costs ($ Million): Reaching for Yield	Hedging Guarantee Exposure	Gross Guarantee Exposure
10%	2,434	757	1,720	471	1,677	-963	1,248
20%	9,735	3,028	6,879	1,886	6,707	-3,851	4,993
30%	21,903	6,812	15,477	4,243	15,091	-8,665	11,234
40%	38,939	12,111	27,514	7,542	26,829	-15,404	19,972

Shock to Illiquid Bonds

- Shocks to illiquid bonds of 2-8% (proportional to capital requirement, relative to stock market shocks of 10-40%) would result in actual insurers selling $107-$431 billion of illiquid bonds.
- The fire-sale costs are 1%-19% of insurers' total capital

	Fire-Sale Amount ($ Million)				Decomposition of Fire-Sale Amount ($ Million)		
Magnitude of Shock	Actual Portfolio + VAs	Portfolio 1 + Actual VAs	Portfolio 2 + Actual VAs	Portfolio 2 + No VAs	Reaching for Yield	Hedging Guarantee Exposure	Gross Guarantee Exposure
2%	107,805	59,493	52,898	52,898	48,312	6,595	0
4%	215,610	118,986	105,797	105,797	96,624	13,189	0
6%	323,415	178,479	158,695	158,695	144,936	19,784	0
8%	431,220	237,972	211,594	211,594	193,248	26,378	0

	Fire-Sale Costs ($ Million)				Decomposition of Fire-Sale Costs ($ Million)		
Magnitude of Shock	Actual Portfolio + VAs	Portfolio 1 + Actual VAs	Portfolio 2 + Actual VAs	Portfolio 2 + No VAs	Reaching for Yield	Hedging Guarantee Exposure	Gross Guarantee Exposure
2%	2,162	658	520	520	1,503	138	0
4%	8,647	2,633	2,082	2,082	6,013	551	0
6%	19,455	5,925	4,684	4,684	13,530	1,241	0
8%	34,587	10,533	8,328	8,328	24,054	2,206	0

Categorical Shock

- Categorical shocks to all assets would result in insurers selling $236-$943 billion of illiquid bonds, more than the sum of each shock due to externality.
- The fire-sale costs potentially catastrophic. [similar to the financial crisis].

	Fire-Sale Amount ($ Million)				Decomposition of Fire-Sale Amount ($ Million)		
Magnitude of Shock	Actual Portfolio + VAs	Portfolio 1 + Actual VAs	Portfolio 2 + Actual VAs	Portfolio 2 + No VAs	Reaching for Yield	Hedging Guarantee Exposure	Gross Guarantee Exposure
10%	235,653	130,617	155,472	109,662	105,035	-24,855	45,810
20%	471,306	261,235	310,945	219,324	210,071	-49,710	91,620
30%	706,959	391,852	466,417	328,987	315,106	-74,565	137,431
40%	942,612	522,470	621,890	438,649	420,142	-99,420	183,241

	Fire-Sale Costs ($ Million)				Decomposition of Fire-Sale Costs ($ Million)		
Magnitude of Shock	Actual Portfolio + VAs	Portfolio 1 + Actual VAs	Portfolio 2 + Actual VAs	Portfolio 2 + No VAs	Reaching for Yield	Hedging Guarantee Exposure	Gross Guarantee Exposure
10%	10,329	3,173	4,496	2,237	7,156	-1,323	2,259
20%	41,316	12,693	17,984	8,947	28,623	-5,290	9,037
30%	92,961	28,560	40,463	20,131	64,401	-11,903	20,332
40%	165,264	50,773	71,935	35,789	114,491	-21,162	36,146

Shock to Value of Guarantee

- Positive shocks to the value of guarantee of 20-80% (e.g., 2011) would induce actual insurers to sell $115-$459 billion of illiquid bond.
- These effects are exclusively due to the VAs, by construction.
- The costs associated with these fire sales are $2-$39 billion, of which about 72% are attributed to reaching for yield.

	Fire-Sale Amount ($ Million)				Decomposition of Fire-Sale Amount ($ Million)		
Magnitude of Shock	Actual Portfolio + VAs	Portfolio 1 + Actual VAs	Portfolio 2 + Actual VAs	Portfolio 2 + No VAs	Reaching for Yield	Hedging Guarantee Exposure	Gross Guarantee Exposure
20%	114,964	60,588	58,195	0	54,376	2,392	58,195
40%	229,927	121,175	116,391	0	108,752	4,784	116,391
60%	344,891	181,763	174,586	0	163,128	7,177	174,586
80%	459,854	242,351	232,782	0	217,504	9,569	232,782

	Fire-Sale Costs ($ Million)				Decomposition of Fire-Sale Costs ($ Million)		
Magnitude of Shock	Actual Portfolio + VAs	Portfolio 1 + Actual VAs	Portfolio 2 + Actual VAs	Portfolio 2 + No VAs	Reaching for Yield	Hedging Guarantee Exposure	Gross Guarantee Exposure
20%	2,458	683	630	0	1,776	53	630
40%	9,833	2,731	2,520	0	7,102	211	2,520
60%	22,125	6,145	5,669	0	15,980	476	5,669
80%	39,333	10,925	10,079	0	28,408	846	10,079

Remaining Discussion Points

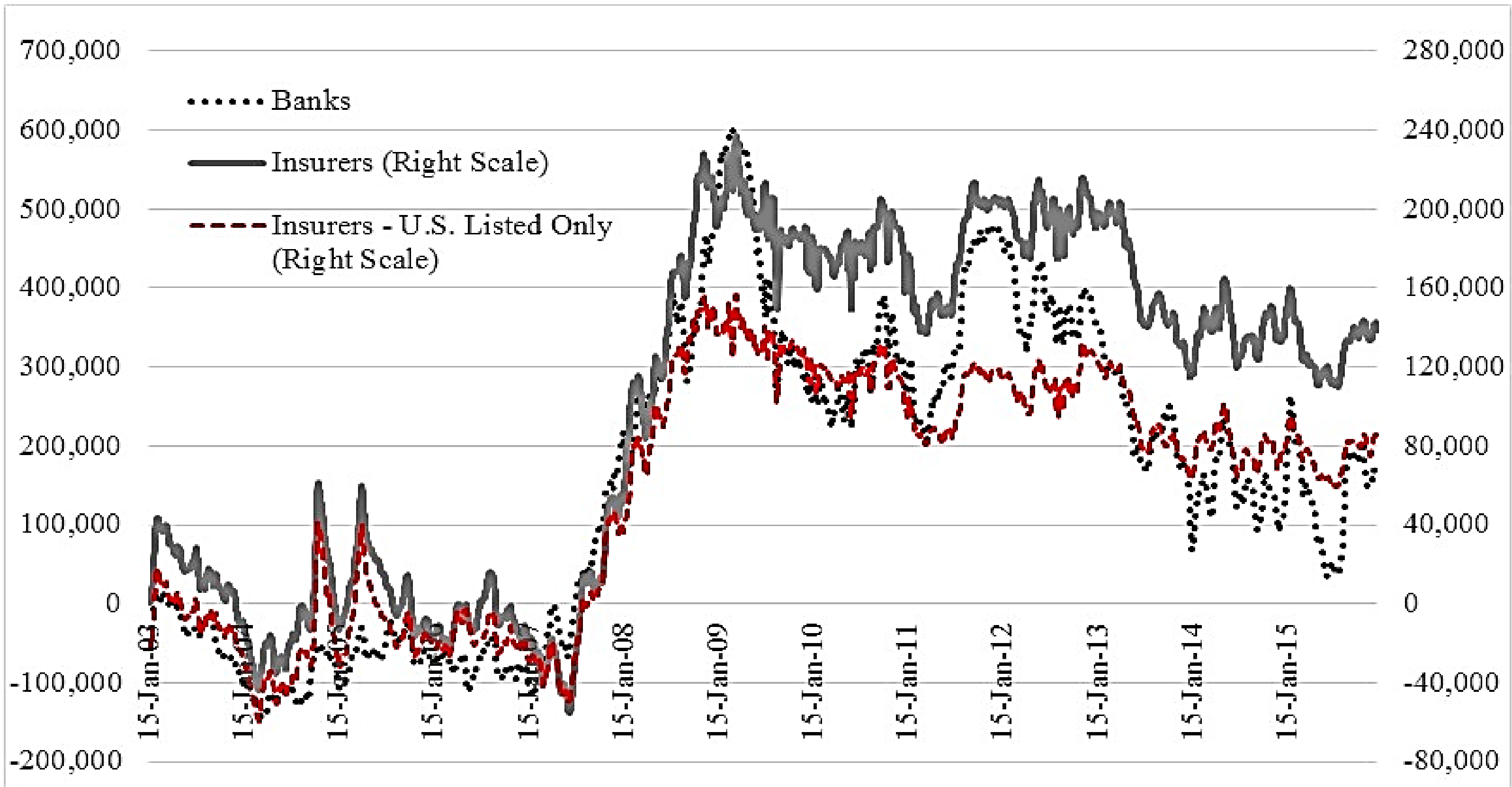
- Direct capital adequacy implications of VAs with guarantees (and other business risks)? [Appendix B]
- Delta hedging in the face of a varying delta itself.
- Accounting Treatment: HCA vs. MTM
- Spillovers outside life insurers: P&C, Banks, derivative counterparties, etc.
- Generalizability of guarantees…

Conclusions

- **Why are FIs inter-connected on the asset side?**
- Propose an innovative mechanism: An incentive that arises from the financial institutions' business model (pervasive guarantees.)
  - A theoretical model that captures the underlying economics and then calibrate the model by using insurer-level data.
- Correlated holdings in Illiquid assets emerge in equilibrium, raising the likelihood of fire sales in the event of common shocks.
- **Message**: VAs with guarantee make life insurers less likely asset insulators (Chodorow-Reich et al. (2017)) and more likely contributor to systemic risk.
  - Similar guarantees and mechanism exist in various financial institutions!

Insurers' Systemic Risk

- Banks' systemic risk seems to have significantly decreased for individual banks and the industry…but **remains elevated for some insurers**



Insurers and Recent Equity Market Turmoil

Why insurers are being blamed for equity market instability

FT 22/02/2018

Market strategists and industry analysts say a post-crisis change to the way US life insurers manage billions of customer dollars invested in variable annuities (VAs) has been a primary source of the instability. ... For the companies that remained in the business [after the crisis], there was a need to find a way to meet demand for such guarantees while avoiding a rerun of the crisis. In 2011 the VA industry introduced managed volatility funds, also known as “target vol” funds. … The recent market swoon happened at a time when the economic fundamentals were solid. Some analysts fret that the more fuel these funds pour on the fire, the more damaging it will be when markets are contending with a bigger conflagration.

Wall St blames turmoil on insurers’ volatility strategy

FT 14/02/2018

Wall Street is pointing the finger at insurance companies as an unlikely but pivotal source of the turbulence that wiped trillions of dollars off stock market values in recent days. .. strategists and investors said a significant portion of the selling could be traced to variable annuities, a popular tax-advantaged insurance company product that offers customers guaranteed returns.

VAs with Guarantees

- Guaranteed minimum death benefit (GMDB)
  - Policyholder purchases $150,000 variable annuity and selects a GMDB. Following poor capital market performance, the value of the account is $75,000 in 10 years. A policyholder dies in year 10 of the policy. Beneficiary receives $150,000
- Guaranteed lifetime withdrawal benefit (GLWB)
  - Policyholder purchases $150,000 variable annuity and a GLWB of 4% annually. Following poor capital market performance, the value of the account is $75,000 in 10 years. Policyholder is in a good position though because she will receive $6,000 (4%*150,000) for lifetime; the lifetime income is guaranteed and not limited to $150,000
- Guaranteed minimum income benefit (GMIB)
  - Policyholder purchases $150,000 variable annuity and selects a GMIB that provides 4% annually. Following poor market performance, the variable annuity contract value is only $75,000 at the end of 10 years. But a policyholder has $222,036 to annuitize as a result of the GMIB

VAs with Guarantees

- Guaranteed minimum withdrawal benefit (GMWB)
  - Policyholder purchases a $150,000 variable annuity and selects a GMWB that provides 4% annually. Following poor capital market performance, the variable annuity contract value is only $75,000 at the end of 10 years. A policyholder is in a good position though because she will receive $6,000 ($150,000 x 4%) per year until the $150,000 is recovered

- Guaranteed minimum accumulation benefit (GMAB)
  - Policyholder purchases a $150,000 variable annuity and selects a GMAB. Following poor capital market performance, the variable annuity contract value is only $75,000 at the end of 10 years. A policyholder is in a good position though because the variable annuity contract value is still $150,000 at the end of 10 years

Without Reaching for Yield

- Portfolio 1, on average, allocates 0.109 less to illiquid bonds and 0.109 more to liquid bonds → Effects of reaching for yield.
- Compared to the portfolio of insurers with no VAs, Portfolio 1 allocates 0.045 less to common stocks, reshuffling that amount to liquid and illiquid bonds

	Portfolio 1: Same Level of Guaranteed VA and Hedge Ratio; No Reaching for Yields			Portfolio 2: No Guaranteed VA		
	Mean	Mean - Actual	Mean - Actual of No VA Insurers	Mean	Mean - Actual	Mean - Actual of No VA Insurers
Liquid bonds	0.762***	0.109***	0.025*	0.718***	0.065***	-0.019
	(0.014)	(0.015)	(0.015)	(0.021)	(0.022)	(0.021)
Illiquid bonds	0.217***	-0.109***	0.021	0.221***	-0.105***	0.025
	(0.036)	(0.037)	(0.037)	(0.018)	(0.019)	(0.019)
Common stock exposures	0.000	0.000	-0.045***	0.039***	0.038***	-0.007***
	(0.001)	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)
Other assets	0.017***	0.000	-0.004	0.019***	0.002	-0.002
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)

Without Guarantee Exposures

- Portfolio 2 has significantly less illiquid bonds and more liquid bonds and common stocks than actual.
- By calibration, Portfolio 2 looks quite similar to the actual portfolio of insurers that do not write VAs.

	Portfolio 1: Same Level of Guaranteed VA and Hedge Ratio; No Reaching for Yields			Portfolio 2: No Guaranteed VA		
	Mean	Mean - Actual	Mean - Actual of No VA Insurers	Mean	Mean - Actual	Mean - Actual of No VA Insurers
Liquid bonds	0.762***	0.109***	0.025*	0.718***	0.065***	-0.019
	(0.014)	(0.015)	(0.015)	(0.021)	(0.022)	(0.021)
Illiquid bonds	0.217***	-0.109***	0.021	0.221***	-0.105***	0.025
	(0.036)	(0.037)	(0.037)	(0.018)	(0.019)	(0.019)
Common stock exposures	0.000	0.000	-0.045***	0.039***	0.038***	-0.007***
	(0.001)	(0.003)	(0.002)	(0.001)	(0.003)	(0.002)
Other assets	0.017***	0.000	-0.004	0.019***	0.002	-0.002
	(0.002)	(0.003)	(0.003)	(0.002)	(0.003)	(0.003)