SRISK as a Measure of Systemic Risk for Insurers: Oversimplified and Inappropriate*

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The SRISK measure has been used to measure the relative systemic risk for financial institutions, ranking some insurers as vulnerable as banks to large capital shortfalls in stressed macroeconomic environments. This paper argues that the assumptions underpinning the SRISK measure are inappropriate for insurers and hence do not depict an accurate representation of insurer systemic risk.

* Support for this research was provided by MetLife

I. Summary

Acharya *et al* define SRISK as a macro-finance measure of systemic risk to furnish "an estimate of the amount of capital that a financial institution would need to raise in order to function normally if we have another financial crisis."[1] SRISK measures the "expected capital shortfall" of an institution during a financial crisis, defined as the "projected market capitalization" if equity markets declined by 40% based on historical stock market correlations (i.e. equity beta) minus the "prudent market capitalization," defined as greater than or equal to 8% of total assets, a leverage ratio.

Acharya and Richardson use SRISK to argue that select insurers are as vulnerable to large capital shortfalls as are banks in stressed macroeconomic environments.[2] In this paper, we argue the inappropriateness of SRISK as a measure of systemic risk for insurers.[3]

The principal arguments of this paper are that:

- **SRISK measures only vulnerability, not the potential for an institution to cause or transmit systemic risk.** Systemic risk can occur when actions by an institution threaten the health of other financial institutions or the stability of the financial system; as designed, the SRISK measure only shows whether an institution may be vulnerable to failure in a period of macro-economic stress, not whether its loss in market capitalization or distress would transmit systemic risk. Further, the high-level assumptions in the SRISK measure ignore differences between the business models of different types of financial institutions, such as the types of assets and liabilities held, and therefore the metric cannot provide this type of assessment. The SRISK measure entirely ignore the fact that contagion

[1] Viral Acharya et al. *SRISK As A Macro-Finance Measure Of Systemic Risk*, <https://bfi.uchicago.edu/sites/default/files/file_uploads/%234.pdf>

[2] Viral Acharya & Matthew Richardson, *Is the Insurance Industry Systemically Relevant?*, in MODERNIZING INSURANCE REGULATION, Chap. 9 (2014).

[3] We focus on the use of SRISK to compare the systemic risk of insurers and banks in this paper. However, many of the arguments put forth will also limit the usefulness of SRISK for comparing the systemic risk of banks, particularly when two institutions have significantly different business models and/or sources of funding.

rather than connectedness is the major threat to the financial system, and capital requirements, at any reasonable level, will be insufficient to forestall or resist, contagious runs.[4]

- **SRISK does not accurately measure an institution's capital shortfall during stress.** The measure assumes that an insurer would manage its business to sustain an 8% ratio of market capitalization to total assets, implying that a decline in market capitalization would require the institution to raise capital or sell assets. This argument assumes a significant drop in market price is a correct measure of real capital. It also fails to reflect significant differences between market capitalization and insurance regulatory capital across all major insurance operating regulatory regimes. This relationship is evidenced by experience in the 2008-9 financial crisis, when many insurers' market capitalizations dropped precipitously without a meaningful decline in regulatory capital or the volumes of new business written.

The next sections of this paper further describe the SRISK measure and then explain the principle arguments above to show that the SRISK measure is not appropriate for measuring systemic risk of insurers.

II. Overview of the SRISK Measure[5]

Acharya, Engle, and Richardson (2012) describe a methodology for computing SRISK that focuses on the expected capital shortfall of a firm in a financial crisis. The methodology consists of two primary steps: (1) estimating the decline in an institution's capital during a financial crisis and (2) calculating the expected capital shortfall based on this decline.

First, the decline in an institution's capital level is estimated. The authors use a firm's equity returns and those of a broad market index to define the relationship between an institution's market capitalization and broader financial markets. The authors then simulate market outcomes over a six-month period. Scenarios in which the broader market index falls at least 40 percent are deemed to represent a

[4] Hal Scott, CONNECTEDNESS AND CONTAGION (2016).

[5] See Appendix for further detail on the calculation of SRISK.

financial crisis; for those scenarios, the expected decline in market capitalization is called the Long Run Marginal Expected Shortfall, LRMES. The authors state that this methodology captures in a single measure many of the characteristics considered important for systemic risk such as size, leverage, and interconnectedness.

Second, the expected capital shortfall during a financial crisis is determined. The authors assume a prudential capital ratio to be 8 percent, then calculate a required capital metric as 8 percent of the firm's debt plus equity, where:

- Debt is the book value of debt and assumed to be relatively unchanged during a financial crisis[6]
- Equity is the firm's market capitalization in a financial crisis

The authors then calculate SRISK as the difference between this "prudent" capital level and the simulated market capitalization in a financial crisis.

III. SRISK Measures Vulnerability, not the Potential for an Institution to Cause or Transmit Systemic Risk

Systemic risk, due to connectedness, occurs, by definition, when distress at an institution causes a threat to the stability of other financial institutions or the financial system. Even if properly defined (which we will discuss in Section IV), a measure of the potential capital needs during a financial crisis, such as SRISK, would fail to assess whether an institution creates or transmits systemic risk. Further, the connectedness dimension of systemic risk was not important in the 2008 crisis, where the real threat was from contagion.[7] The SRISK measure entirely ignores contagion.

The factors captured within the SRISK measure, such as size, capitalization, leverage, and market correlation, only demonstrate the potential for a capital shortfall during stress and therefore show the vulnerability of an institution to failure. Large financial institutions are therefore inherently prone to a

[6] This assumption is reasonable for banks, whose primary liability is deposits, and insurers which value at book-value; it does not hold for insurers which value liabilities at market-value.

[7] See Scott, *supra* note 4.

high ranking regardless of their business model.[8] However, to pose systemic risk, the failure of an institution must pose a threat to other financial market participants or the overall financial system. SRISK does not make any assessment of this threat.

There are three conventional transmission channels for systemic relevance, shown below in Table 1:

Table 1: Measures of systemic relevance[9]

Criteria	Definition	Systemic relevance
Exposure	Linkages between a firm and other components of the financial system	Losses at other financial institutions due to direct counterparty exposure
Asset Liquidation	Potential for rapid sale of assets at "fire-sale" prices	Disruption of markets due to the losses imposed by fire sales
Critical function or service	Extent to which other firms can provide the same services in event of a failure	Disruption of market function due to inability or unwillingness of other firms to provide critical services

As constructed, SRISK omits entirely an assessment of the conventional transmission channels for systemic risk. The lack of a systemic risk assessment is particularly important when the authors apply SRISK to compare the systemic relevance of firms across multiple types of financial institutions[10].

SRISK does not consider how these transmission channels may differ across types of financial institutions, such as between banks, broker-dealers, and insurers – despite the significant differences in the business models of these institutions. For example, consider the interconnectedness transmission channel: systemic relevance for this channel can be measured as the counterparty exposure of other financial institutions to a firm. As illustrated below in Figure 1, a significantly lower portion of insurer

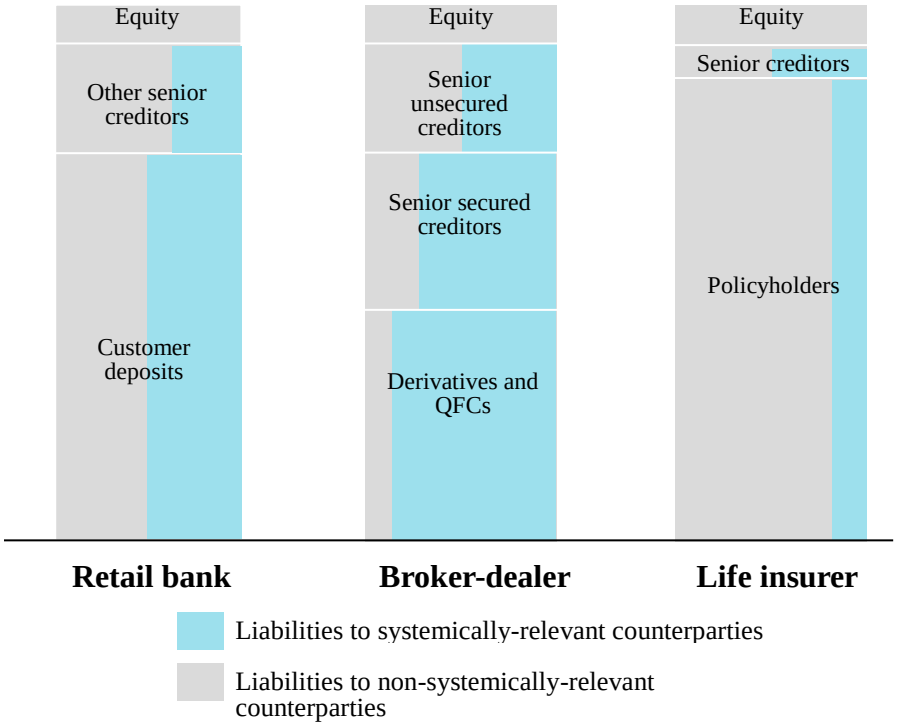
[8] Scott Harrington & Alan Miller, *Designation and Supervision of Insurance SIFIs,* in MODERNIZING INSURANCE REGULATION, Chp.89 (2014).

[9] 12 C.F.R. § 1310.

[10] *See, e.g.,* Acharya et al, *supra* n.1*;* Acharya, Viral, Robert Engle and Matthew Richardson. 2012. "Capital Shortfall: A New Approach to Ranking and Regulating Systemic Risks." American Economic Review, 102(3):59-64 (using SRISK to compare systemic risk associated with individual institutions); Acharya & Richardson, *supra* n.2 (using SRISK to compare systemic relevance of the insurance sector versus total financial sector).

liabilities are held by systemically-relevant counterparties than for retails banks or broker-dealers. Therefore, for institutions with a similar size, leverage, or market capitalization, the level of interconnectedness is significantly lower for an insurer than for either a retail bank or broker dealer.

Figure 1: Illustration of the systemic sensitivity of bank counterparties compared to life insurers[11]



An assessment of the asset liquidation transmission channel yields similar conclusions: insurers hold relatively liquid investment portfolios, with high concentrations of securities, and the holdings of individual institutions do not represent a significant share of the markets for these securities. As a result, these assets would have negligible systemic impact upon liquidation.

[11] Oliver Wyman analysis.

Table 2: 2014 year-end asset allocations for the insurance industry[12]

Asset Class	Holdings ($ BN)	Allocation %
Bonds	3,859	67.0%
U.S. Government bonds	*244*	*4.2%*
Corporate bonds	*2,061*	*35.8%*
Municipal bonds	*541*	*9.4%*
RMBS, CMBS, ABS	*884*	*15.4%*
Foreign gov't bonds	*103*	*1.8%*
Hybrid securities	*25*	*0.4%*
Stock	709	12.3%
Mortgages, first lien	393	6.8%
Cash and short-term investments	228	4.0%
Contract loans	133	2.3%
Other assets	439	7.6%
Total	**5,762**	**100%**

SRISK does not account for the liquidity of asset holdings and therefore renders an incomplete measure of systemic risk by asset liquidation by an insurer or any other institution. Further, individual institutions do not hold a significant share of assets in any market. As shown below, the holdings for the top-3 insurers, in aggregate, represent only a small portion of securities markets.

[12] NAIC Capital Markets Bureau Special Report. Accessed <http://www.naic.org/capital_markets_archive/150622.htm>.

Table 3: Top-3 insurer securities versus total outstanding notional amount[13]

Asset Class	Top 3 Insurers ($ BN)	Outstanding ($ BN)	% Market
Bonds	579.8	*39,017*	*1.5%*
U.S. government	*60.5*	*14,533*	*0.4%*
Corporate (incl. hybrids)	*347.7*	*7,830*	*4.4%*
Municipal	*39.8*	*3,652*	*1.1%*
RMBS, CMBS, ABS	*106.6*	*10,097*	*1.1%*
Foreign government	*14.4*	*n/a*	*n/a*
Stock	10.8	36,256	0.0%

Furthermore, systemic concerns from the asset liquidation channel assume that an institution would rapidly deleverage its balance sheet; this is not the case for insurers for two reasons:

- Many liabilities (e.g., insurance policies and long-term debt) cannot be accelerated or withdrawn (i.e. they are not prone to runs)
- Other liabilities (e.g., select investment-oriented policies) require the consent of policyholders – most of which are designed to offer benefits only over a long-term and contain provisions that discourage policyholders from withdrawing even in the event of an insurer failure

Insurance products can generally be categorized into surrenderable liabilities and non-surrenderable liabilities. Surrenderable liabilities offer the policyholder an ability to withdraw or receive upon surrender a cash value. These liabilities, which include fixed annuities and universal life products, have varying levels of disincentives[14] which discourage a policyholder from surrendering or withdrawing an available cash value. For example, a policyholder who forfeits a guarantee universal life product may lose insurance coverage, forfeit their guarantee, and incur surrender charges. Non-surrenderable liabilities includes those contracts for which cash flows cannot be accelerated due either to a fixed payment

[13] SIFMA, 2015 Fact Book, *available at http://www.sifma.org/research/statistics.aspx;* SNL Financial.

[14] Disincentives include loss of insurance coverage, forfeiture of guarantees, tax penalties.

schedule (e.g., income annuities) or payments that occur only upon an event such as death or disablement. These liabilities are extremely illiquid and could not be de-leveraged during a financial crisis.

Table 4 below shows the average percent allocations of insurance products (life products only) based on statutory reserves for 3 large insurers.

Table 4: Allocation of product types among top 3 insurers and product surrenderability[15]

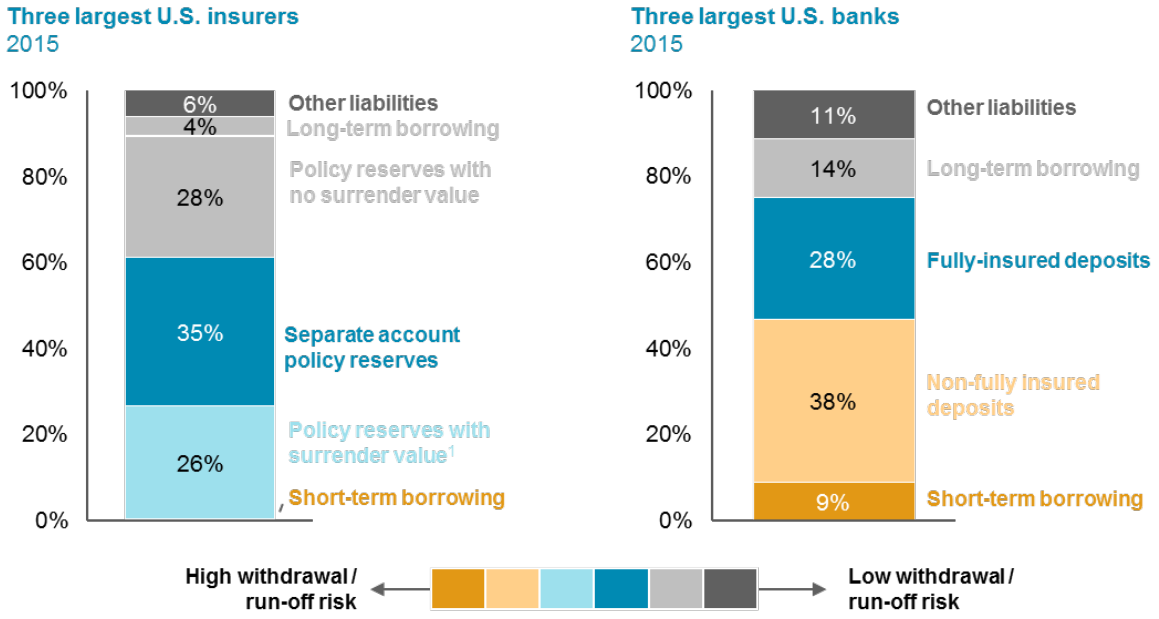
Product	Allocation (%)	Surrenderability and disincentives
General Account Liabilities	*44.3%*	
Accident & Health Contracts	2.4%	Non-surrenderable
Group Life	0.8%	Non-surrenderable
Group Annuities & Deposit-Type Contracts	18.4%	Generally non-surrenderable16
Individual Fixed Annuities	12.1%	Surrenderable, low disincentives
Individual Fixed Life	10.5%	Surrenderable, modest to high disincentives
Separate Account Liabilities	*55.7 %*	
Group Annuities & Deposit-Type Contracts	20.1%	Varies by product
Variable Annuities	25.7%	Surrenderable, modest to high disincentives
Variable Life	10.0%	Surrenderable, high disincentives

As shown in the table above, the majority of insurer liabilities either cannot be surrendered or contain significant disincentives that would discourage policyholders from surrendering during periods of market stress. In contrast, a significant portion of banking liabilities are either non-fully insured deposits or short-term borrowing, which can easily be withdrawn. Further, only the surrender of guaranteed separate account liabilities would impact an insurer. And for many types of guarantees, there would be little incentive to surrender the guarantee that would still have value, which would be forfeited by surrendering.

[15] Based on 2015 YE reserves. Insurer statutory filings (via SNL Financial).

[16] There is an ability to withdraw funds on some contracts.

Figure 2: Withdrawal and surrender characteristics of banking and insurance liabilities[17]



Note: 1. May include features that discourage surrender, such as loss of insurance protection or guarantees

As shown in Figure 2 above, for the three largest institutions, only 26% of insurer liabilities (policy reserves, i.e. life insurance policies with cash surrender value) are withdrawable, compared with 47% for banks (non-fully insured deposits and other short-term borrowing). Further, it is common for insurance contracts to afford the insurer the ability to delay payment by up to six months, which would limit the potential for immediate liquidity needs in the event of severely elevated surrenders. Thus, even with impending failure of the insurer, an insurer would not expect to rapidly deleverage its balance sheet and therefore impact asset prices from fire-sales.

Lastly, the insurance market (with the exception of a few narrow lines) is not concentrated. There are over 2,000 insurance groups in the U.S. and the three largest insurers in each business line do not dominate the market.

[17] SNL Financial. Three U.S. insurers and banks defined based on total assets (excludes Berkshire Hathaway); breakdown on insurance policy reserves estimated based on U.S. statutory reserves.

Table 5: Insurance market concentration – share of largest three insurers by business line (2015)[18]

Product line	Premium	Reserves
Life	28%	30%
Annuities	21%	28%
Commercial P&C	19%	n/a
Personal P&C	37%	n/a

Therefore, the critical function and service transmission channel – which primarily targets market infrastructure companies – does not give rise to systemic risk concerns within the insurance industry.

IV. SRISK Does Not Accurately Measure an Institution's Capital Shortfall During Stress

A predicate of the SRISK measure is that a financial institution would maintain a market capitalization of at least 8% of total assets. This assumption asserts that a decline in market capitalization would spur an institution to raise capital (or deleverage in proportion to the loss of market capitalization).

This methodology fails to distinguish between an insurer's market capitalization and regulatory capital requirements. For life insurers, solvency and financial strength of an insurer are measured by statutory capital requirements and not by market capitalization. Because of the long-term nature of the insurance business model, insurance regulators globally have taken measures to limit pro-cyclicality in insurer capital levels, creating a meaningful disconnect with insurer market capitalizations. Irrespective of one's view on what the regulatory framework should be, this disconnect violates a predicate of the SRISK measure by separating a decline in market capitalization from an insurer need to raise additional capital. The extent of differences between market capitalization and regulatory capital varies depending on the capital regime in effect across each jurisdiction. Table 6 below describes the capital regimes across several regions.

[18] Largest three firms vary by product line and metrics. Include firms are: life reserves (Northwestern Mutual, New York Life, MetLife), life premiums (Northwestern Mutual, New York Life, Prudential), annuity reserves (TIAA, AIG, MetLife), annuity premiums (Jackson, Prudential, AIG), commercial P&C (AIG, Travelers, Chubb), and personal P&C (State Farm, AllState, Berkshire Hathaway). Statutory filings (via SNL Financial) for 2015 YE.

Table 6: Capital regimes for insurers in various global markets[19]

Capital Regime	Country	Asset valuation basis	Liability valuation basis	Insurer Assets by country (TN)
Risk Based Capital (RBC)	United States	Book value	Book value	$8.13
Solvency II	The European Union	Market value	Market value[20]	$7.57
Solvency Margin Ratio	Japan	Book or market depending on asset type	Book value	$4.60
Bermuda Solvency Capital Requirement (BSCR)	Bermuda	Market value	Market value	$0.61
Life Minimum Continuing Capital and Surplus Requirements (MCCSR)	Canada	Carrying value[21]	Book value	1.47 CAD
Swiss Solvency Test (SST)	Switzerland	Market value	Market value	$0.54

If valued at market value, such as under Solvency II, regulatory capital levels may be sensitive to market movements – though, even while market value-oriented, Solvency II contains numerous provisions to limit procyclicality that make it less market-sensitive than insurer market capitalization. These provisions include the matching adjustment (which increases the discount rate on certain insurance liabilities to portfolio yields) and the volatility adjustment (which increases the liability discount rate by a credit spread). The effect of increases in the discount rate on liabilities is to lower their overall value and thus increase the amount of capital.

If valued at book value, such as under the United States RBC, assets and liabilities would move little in response to changes in the markets, and therefore would not move as market capitalization

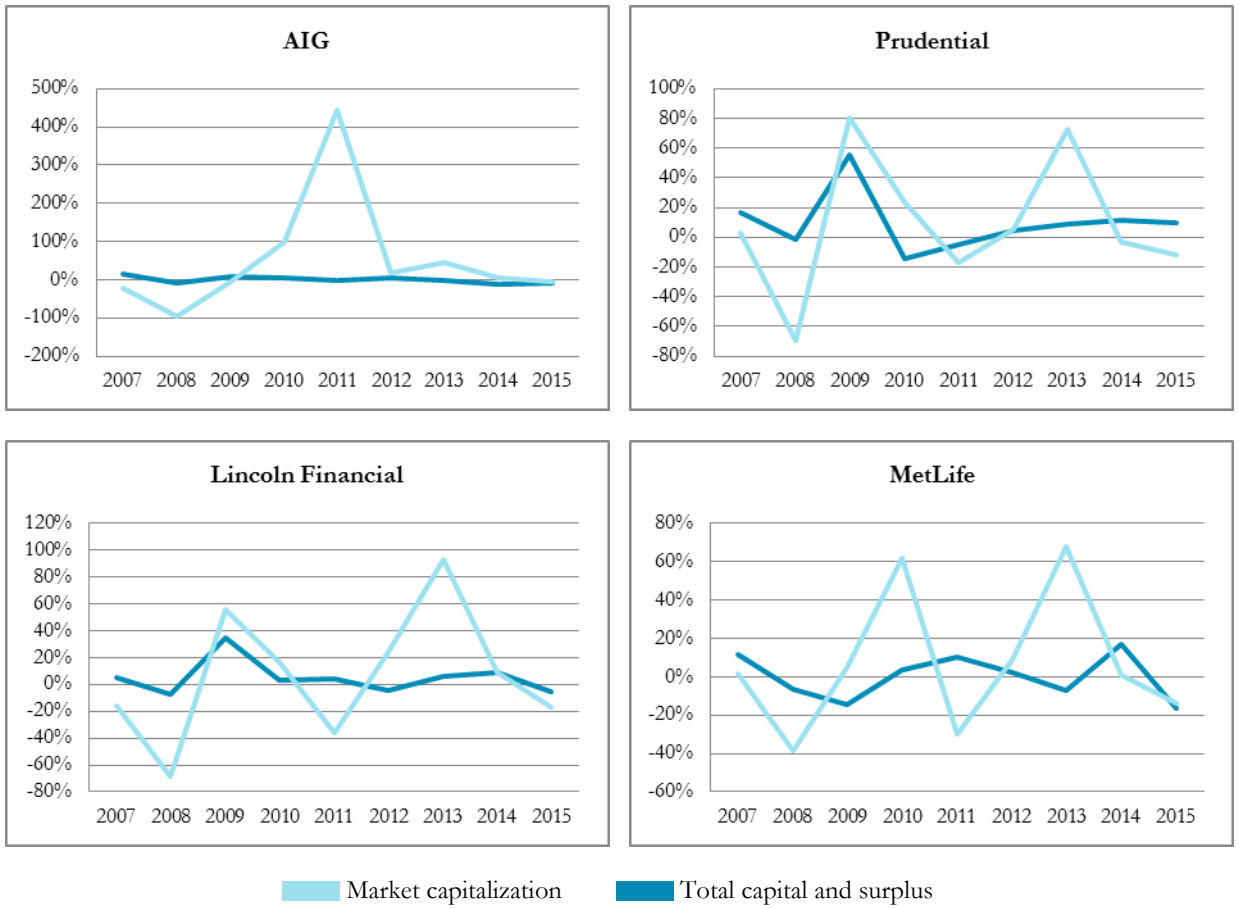
[19] US – YE 2015, SNL Financial. EU – YE 2015 from European Central Bank, FX rate of 1.089 USD per EUR from OANDA. Japan – YE 2015 Flow of Funds Report by Bank of Japan, FX rate from OANDA of 0.0083 JPY to USD. Bermuda – YE 2013, Bermuda Monetary Authority. Canada – YE 2015, OSFI. Switzerland – YE 2014, Financial Stability Board.

[20] Solvency II, while market value-oriented, contains numerous provisions to limit procyclicality that result in deviations from insurer market capitalization

[21] Between book and market values.

changes. This is reflected in Figure 3 below, showing the year-on-year changes in market capitalization and total capital and surplus for four large U.S. insurers: AIG, Prudential, Lincoln Financial, and MetLife.

Figure 3: Year-over-year changes in market capitalization[22] and total capital and surplus[23] for AIG, Prudential, Lincoln Financial, and MetLife



As shown above, the SRISK predicate that an insurer's capital would change in-line with market capitalization does not hold in practice. In addition, another threshold issue with the SRISK reliance on market prices is how long the regulators should require the low market price to persist before mandating a

[22] Market capitalization (source: SNL Financial) for insurance groups; reflects both insurance and non-insurance entities.

[23] Regulatory capital for U.S. insurance entities (source: SNL Financial). MetLife estimated as the sum of its two largest subsidiaries, Metropolitan Life Insurance Company and MetLife Insurance Company USA. Includes U.S. entities only: AIG's non-life business is 45% international (excluding US, Canada, LatAm, Caribbean) by net written premiums; AIG's life business is 4% international (non-Americas) by premiums and deposits; Prudential is 23% international (non-U.S.) by assets; Lincoln Financial does not have any non-U.S. operations; MetLife is 23% international (non-U.S.) by assets. Company 10-K filings (2015).

response. Is an intraday drop in market price sufficient to trigger mandated action, or must it remain low for a longer period of time, measured in days, weeks or months? Furthermore, even if an insurer sought to raise capital due to impairments to book value of rises in guaranteed costs, unless it is approaching minimum regulatory-required levels of capital, raising capital would be a choice as opposed to a need, as implicitly assumed in the SRISK model. A comparison of insurers' SRISK on Dec. 31, 2007 to the amount of capital raised during the financial crises shows little relationship:

Table 7: Insurer SRISK versus capital raised during financial crisis[24]

	SRISK (Dec. 31, 2007)	**Capital raised** (2008-2010)
American International Group (including non-insurance entities)	11.2	54.9[25]
MetLife	20.5	7.9
Prudential	14.9	2.6
Hartford	13.5	7.8
Lincoln National Corporation	7.1	1.1

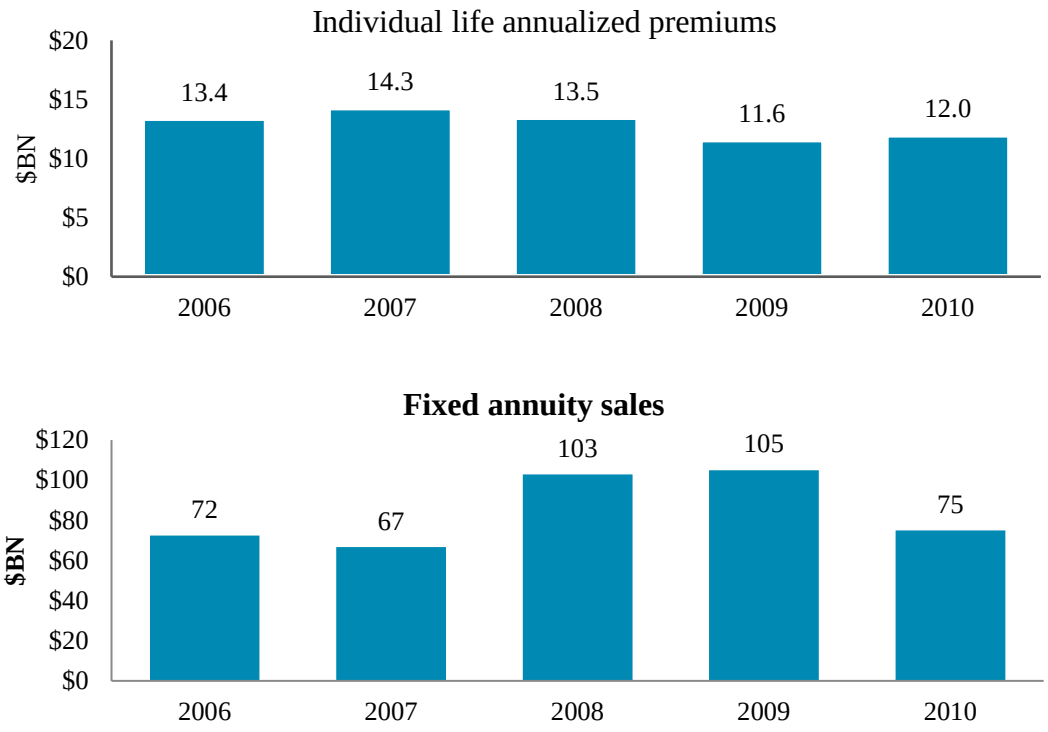
We note that the above does not distinguish the reasoning for capital raises; for example, both MetLife and Prudential conducted significant acquisitions (purchasing units from AIG) during the financial crisis.

Further, although their market capitalization declined, insurers continued to conduct significant new business. As show below in Figure 4 premiums across the industry were largely unaffected by the financial crisis. The ability for insurers to continue to sell new business demonstrates both that customers continue to have confidence in the insurers' abilities to fulfill policy commitment and that these institutions have sufficient capital and surplus to absorb capital strain associated with new sales.

[24] SRISK as-of December 31, 2007 (NYU Stern, http://vlab.stern.nyu.edu/analysis/RISK.USFIN-MR.MES, accessed June 26, 2016). Capital raised based on proceeds from common and preferred equity issuance in 2008 - 2010(source: SNL Financial).

[25] Includes $40 BN in preferred stock issued to the U.S. Department of Treasury under the Troubled Asset Relief Program (TARP)

Figure 4: Individual life annualized premiums and fixed annuity sales, 2006 - 2010[26]



V. Acharya's More Recent Work

Acharya's more recent work on the insurance industry and systemic risk focuses less on applying the SRISK measure to insurance companies and more on the idea that a financial crisis would affect a major insurer through a flow-of-funds chain.[27] The idea is that an insurer with less capital would change its business mix to seek higher yields, by paying less for corporate bonds and CMBS, thus increasing their yields and the cost of capital for the real economy. In addition, insurance premiums would be repriced, leading to increased insurance costs. This analysis assumes that insurance companies are significant price makers in the corporate bond market. But as we have seen, the top 3 insurers hold less than 5% of this market. Thus, any systemic risk concerns would need to arise from an industry-wide reduction in credit

[26] Data sourced from JP Morgan Share Bible, Volume LV April 2013. Table 2 -

[27] See Viral Acharya, Are Insurance Firms Systemically Important?, presented at the Stockholm Institute of Financial Research, August 2015, available at http://pages.stern.nyu.edu/~sternfin/vacharya/public_html/pdfs/Acharya%20Systemic%20Risk%20of%20Insurance%20Sector%20-%20August%202015.pdf.

risk taking, not a single (or few) institutions. Further, perhaps the increased yields are not due to hunt for yield by insurers but by the 40% equity market drop that Acharya posits as a financial crisis. And even assuming, insurance companies do bid up the yield of corporate bonds, are the resulting effects enough to have a significant impact on the overall economy?

VI. Conclusion

The SRISK measure has been used to quantify the systemic risk that financial institutions pose and has indicated that large insurers could potentially pose the same levels of systemic risk to the financial system as banks. As shown throughout this paper, SRISK does not provide the means to make this assessment both because it does not attempt to measure the ability of an institution to transmit risk to the financial system or broader economy and because the metric relies on invalid assumptions .

SRISK does not measure the potential for an institution to transmit systemic risk because it only shows that an individual institution could be vulnerable to failure. It ignores several key causation and transmission channels. It additionally applies a uniform approach to all institutions based on high-level and publicly-available data, ignoring the nuances of insurance products and historical proof that distresses in insurers has not led to systemic consequences. The SRISK measure does not account for the fact that an insurer would not need or be able to rapidly deleverage its portfolio, a key assumption of the SRISK measure, due to the types of liabilities it holds.

Furthermore, it inappropriately uses market capitalization as a proxy for an insurer's regulatory capital and strength, which was shown to be an oversimplification and invalid. Over the past 10 years, several large U.S. insurers' RBC and market capitalization have shown no correlation in movement. Additionally, despite several drops in market capitalization for several insurers during the financial crisis, premiums were largely unaffected.

For the reasons above and highlighted throughout this paper, we believe that the SRISK measure is not appropriate for estimating and comparing the systemic risk of life insurers to that of other peer financial institutions.

Appendix: Overview of the SRISK measure

Acharya, Engle, and Richardson (2012) describe a methodology for computing SRISK that focuses on the expected capital shortfall of a firm in a financial crisis:

$$SRISK_{i,t} = E_{t-1}(Capital\ Shortfall_i | Crisis)$$

The methodology consists of two primary steps: (1) estimating the decline in an institution's capital during a financial crisis and (2) calculating the expected capital shortfall based on this decline.

First, the decline in an institution's capital levels is estimated[28]. The authors use a bivariate daily time series model of equity returns for a firm, *i*, and those of a broad market index, *m*, to define the relationship between an institution's market capitalization and broader financial markets.

$$R_{m,t} = \sigma_{m,t}\varepsilon_{m,t}$$

$$R_{i,t} = \sigma_{i,t}\left(\rho_{i,m,t}\varepsilon_t + \sqrt{1-\rho_{i,m,t}^2}\xi_{i,t}\right)$$

$$(\varepsilon_t, \xi_{i,t}) \sim F$$

The methodology simulates market outcomes over a six-month. Scenarios in which the broader market index falls at least 40 percent are deemed to represent a financial crisis; for those scenarios, the expected decline in market capitalization is called the Long Run Marginal Expected Shortfall, *LRMES*.

Second, the expected capital shortfall during a financial crisis is determined. The authors assume a prudential capital ratio, *k*, to be 8 percent, then calculate a prudent capital requirement as 8 percent of the firm's debt plus equity:

$$Prudent\ Capital = k\ (Debt + Equity) | Crisis$$

Where,

- *Debt* is the book value of debt and assumed to be relatively unchanged during a financial crisis
- *Equity* is the firm's market capitalization in a financial crisis

[28] NYU's Volatility Lab, which maintains a ranking of firm's systemic risk based on the SRISK methodology, updated the methodology used to calculate LRMES in 2016. Under the revised methodology, LRMES equals

$$LRMES = 1 - e^{\ln(1-d)\beta}$$

Where *d* is the decline in market indices corresponding to a financial criris (40%) and β is the firm's Dynanic Conditional Beta. While these revisions increase transparency in the calculation, they do not represent a significant conceptual change in the methodology. *See* NYU's V-Lab, https://vlab.stern.nyu.edu/ (accessed Nov. 6, 2016).

The authors the calculate SRISK as the difference between this prudent capital level and the simulated market capitalization in a financial crisis.

$$SRISK_{i,t} = E\big((k(Debt + Equity) - Equity)\big|Crisis\big)$$

$$SRISK_{i,t} = k\big(Debt_{i,t}\big) - (1-k)\big(1 - LRMES_{i,t}\big)Equity_{i,t}$$