Portfolio Similarity and Asset Liquidation in the Insurance Industry

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Background

Following the global financial crisis, the U.S. Congress passed the Dodd-Frank Wall Street Reform and Consumer Protection Act of 2010 that gave the newly formed Financial Stability Oversight Council (FSOC) the authority to:

- Designate Systemically Important Financial Institutions (SIFIs)
- subject them to enhanced prudential standards with the goal of limiting the impact of their distress on financial stability
Motivation

- SIFI designation, among other criteria – size, leverage, liquidity mismatch, substitutability, existing regulatory scrutiny – explicitly considers the interconnectedness of the portfolios of nonbank entities such as insurance companies.
- However, there are no specific guidelines for measuring interconnectedness.
- Following FSOC’s basis for SIFI designation, we focus on commonality in asset holdings as the channel through which interconnectedness arises in the insurance industry.
SIFI Designation of Prudential Financial, Inc.

Basis for the Financial Stability Oversight Council's Final Determination Regarding Prudential Financial, Inc. (emphasis added):

- “A liquidation of a significant portion of Prudentials assets could cause significant disruptions to key markets including the corporate debt and asset-backed securities markets”

- “The severity of the disruption [...] could be amplified by the fact that the investment portfolios of many large insurance companies are composed of similar assets.”
Literature

Prior research identifies as source of interconnectedness in the insurance industry common operational risk, reinsurance, non-traditional investments and short-term financing


Interconnectedness among insurance companies and spillovers are often inferred from CDS spreads or stock returns correlations


Asset liquidation contagion

- Ellul-Jotikasthira-Lundblad 2011, Ambrose-Cai-Helwege 2008: Capital-constrained insurers attempt to improve their regulatory capitals primarily by disposing of recently downgraded corporate bonds
- Herding in some corporate bond subsectors: Chiang and Niehaus (2016), Cai-Han-Li-Li (2016)
Contribution

- We focus on commonality in asset holdings as the channel through which interconnectedness arises in the insurance industry.
- Little empirical evidence has been presented on whether/how much individual insurance companies' portfolios are interconnected (overlapping portfolios).
- Develop methodology for measuring portfolio similarity across insurers' whole investment portfolio by looking both at:
  - Asset class-sectors similarities
  - Asset issuers similarities
Research questions

1. Explore what insurer characteristics affect portfolio similarity
2. Examine whether our measure of portfolio similarity is able to predict insurers selling behaviors
3. Can easily observable metrics - size or return correlation - convey the same information?
4. Understand the link between insurers' portfolio similarity and asset liquidation decisions:
   - Liquidity/Downgrades/Capital req.
5. Develop a tool to monitor interconnectedness of insurance companies portfolios
Data

- NAIC filings - A.M. Best Schedule D
- Corporate and Municipal Bonds, Common and Preferred Stocks, Government Debt held from 2002 to 2014
- Holdings available at the individual 9-digit CUSIP
- Ownership aggregated at the Insurance Group level
## Descriptive Statistics

### Panel A. All Insurer Groups

<table>
<thead>
<tr>
<th>Sector Composition</th>
<th>All Mean</th>
<th>All Median</th>
<th>All SD</th>
<th>Life Mean</th>
<th>Life Median</th>
<th>Life SD</th>
<th>P&amp;C Mean</th>
<th>P&amp;C Median</th>
<th>P&amp;C SD</th>
<th>PSIFI Mean</th>
<th>PSIFI Median</th>
<th>PSIFI SD</th>
<th>Non-PSIFI Mean</th>
<th>Non-PSIFI Median</th>
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<td>0.2</td>
<td>5.6</td>
<td>1.2</td>
<td>0.0</td>
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<td>6.6</td>
<td>5.3</td>
<td>7.8</td>
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<td>0.7</td>
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<td>1.3</td>
<td>0.3</td>
<td>4.9</td>
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<td>5.1</td>
<td>17.9</td>
<td>14.2</td>
<td>9.0</td>
<td>17.2</td>
<td>7.2</td>
<td>4.8</td>
<td>6.4</td>
<td>13.3</td>
<td>7.2</td>
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<td>1.5</td>
<td>0.0</td>
<td>6.7</td>
<td>5.2</td>
<td>0.1</td>
<td>13.8</td>
<td>0.2</td>
<td>0.0</td>
<td>0.3</td>
<td>4.7</td>
<td>0.0</td>
<td>13.1</td>
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<tr>
<th>Issue/Issuer Composition</th>
<th>All</th>
<th>Life</th>
<th>P&amp;C</th>
<th>PSIFI</th>
<th>Non-PSIFI</th>
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<tr>
<td>Number of issues</td>
<td>380</td>
<td>116</td>
<td>1,074</td>
<td>748</td>
<td>174</td>
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<tr>
<td>Number of issuers</td>
<td>250</td>
<td>100</td>
<td>403</td>
<td>440</td>
<td>137</td>
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<table>
<thead>
<tr>
<th>Other Characteristics</th>
<th>All</th>
<th>Life</th>
<th>P&amp;C</th>
<th>PSIFI</th>
<th>Non-PSIFI</th>
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</thead>
<tbody>
<tr>
<td>Sector concentration</td>
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<td>0.26</td>
<td>0.28</td>
<td>0.30</td>
<td>0.12</td>
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<tr>
<td>Issuer concentration</td>
<td>0.16</td>
<td>0.25</td>
<td>0.14</td>
<td>0.12</td>
<td>0.01</td>
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<tr>
<td>TA incl separate accounts ($B)</td>
<td>3.25</td>
<td>23.30</td>
<td>11.19</td>
<td>0.08</td>
<td>47.25</td>
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<tr>
<td>TA excl separate accounts ($B)</td>
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<td>15.42</td>
<td>7.54</td>
<td>0.08</td>
<td>30.67</td>
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<tr>
<td>Investment portfolio ($B)</td>
<td>1.65</td>
<td>10.46</td>
<td>5.05</td>
<td>0.07</td>
<td>19.75</td>
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<td>Number of issuers</td>
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<td>635</td>
<td>1,746</td>
<td>38</td>
<td>2,381</td>
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</table>
Similarity construction

For each insurer create vector of weights of portfolio composition either at the AsclassSec level or the Issuer level

\[
\begin{array}{c|c}
%\text{Issuer}_{1,t} & %\text{AsclassSec}_{1,t} \\
%\text{Issuer}_{2,t} & %\text{AsclassSec}_{2,t} \\
%\text{Issuer}_{3,t} & %\text{AsclassSec}_{3,t} \\
\vdots & \vdots \\
%\text{Issuer}_{n,t} & %\text{AsclassSec}_{n,t} \\
\end{array}
\]
## Asset class-sector composition

<table>
<thead>
<tr>
<th>LIQUID</th>
<th>ILLIQUID</th>
</tr>
</thead>
<tbody>
<tr>
<td>US_Govt</td>
<td>Muni_GO</td>
</tr>
<tr>
<td>Mutual_Funds</td>
<td>Muni_Revenue</td>
</tr>
<tr>
<td>GSE</td>
<td>ABS</td>
</tr>
<tr>
<td>Sovereign_Bonds</td>
<td>RMBS</td>
</tr>
<tr>
<td>Equity_Utility</td>
<td>CMBS</td>
</tr>
<tr>
<td>Equity_Services</td>
<td>Debt_Technology</td>
</tr>
<tr>
<td>Equity_Energy</td>
<td>Debt_Health</td>
</tr>
<tr>
<td>Equity_Undefined</td>
<td>Debt_Services</td>
</tr>
<tr>
<td>Equity_Technology</td>
<td>Debt_Pharma_Chemical</td>
</tr>
<tr>
<td>Equity_Health</td>
<td>Debt_Undefined</td>
</tr>
<tr>
<td>Equity_Basic_Materials_Durable</td>
<td>Debt_Financials_Undefined</td>
</tr>
<tr>
<td>Equity_Pharma_Chemical</td>
<td>Debt_Basic_Materials_Durables</td>
</tr>
<tr>
<td>Equity_Consumer_Staples_retail</td>
<td>Debt_Banks</td>
</tr>
<tr>
<td>Equity_Banks</td>
<td>Debt_Consumer_Staples_retail</td>
</tr>
<tr>
<td>Equity_Financials_Undefined</td>
<td>DebtUtilities</td>
</tr>
<tr>
<td>Equity_GSE</td>
<td>Debt_Insurers</td>
</tr>
<tr>
<td>Equity_Insurers</td>
<td>Debt_Energy</td>
</tr>
</tbody>
</table>
Cosine similarity

- Similarity\(_{i,j,t}\) is then computed as:

\[
\text{Similarity}_{i,j,t} = \frac{w_{i,t} \cdot w_{j,t}}{\|w_{i,t}\| \|w_{j,t}\|}
\]

- Bounded by 0, 1 with 1 being perfectly similar
Cosine similarity: Example

<table>
<thead>
<tr>
<th>Holdings</th>
<th>Prudential</th>
<th>MetLife</th>
<th>AIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford</td>
<td>50%</td>
<td>50%</td>
<td>0%</td>
</tr>
<tr>
<td>GM</td>
<td>25%</td>
<td>50%</td>
<td>0%</td>
</tr>
<tr>
<td>Toyota</td>
<td>25%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

- Prudential and MetLife: 0.87
- Prudential and AIG: 0.41
- MetLife and AIG: 0
Pairwise Portfolio Similarity

(a) Sector Similarity

(b) Issuer Similarity
Quarterly Pairwise Sales Similarity

(a) Sector Similarity - Net Sales

(b) Issuer Similarity - Gross Sales
RQ1: Determinants of pairwise Portfolio Similarity between insurers

<table>
<thead>
<tr>
<th></th>
<th>Sector Similarity</th>
<th>Issuer Level Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (1)</td>
<td>Non-PSIFI (2)</td>
</tr>
<tr>
<td>Life_Pair</td>
<td>0.062*** (7.46)</td>
<td>0.052*** (6.02)</td>
</tr>
<tr>
<td>PC_Pair</td>
<td>0.026*** (5.30)</td>
<td>0.030*** (5.85)</td>
</tr>
<tr>
<td>PSIFI_Pair</td>
<td>0.135*** (18.32)</td>
<td></td>
</tr>
<tr>
<td>Non-PSIFI_Pair</td>
<td>0.049*** (6.64)</td>
<td></td>
</tr>
<tr>
<td>Big_Pair</td>
<td></td>
<td>0.075*** (13.62)</td>
</tr>
<tr>
<td>Small_Pair</td>
<td></td>
<td>-0.029*** (-12.74)</td>
</tr>
<tr>
<td>Conc_Pair_S</td>
<td>-0.031*** (-4.87)</td>
<td>-0.017*** (-3.20)</td>
</tr>
<tr>
<td>NonConc_Pair_S</td>
<td>0.138*** (19.68)</td>
<td>0.114*** (20.21)</td>
</tr>
<tr>
<td>Conc_Pair_I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>NonConc_Pair_I</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Constant</td>
<td>0.385*** (-130.21)</td>
<td>-0.103*** (-118.17)</td>
</tr>
<tr>
<td>Year FE</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>N</td>
<td>10,605,566</td>
<td>10,077,756</td>
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<tr>
<td>R²</td>
<td>0.092</td>
<td>0.105</td>
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RQ2: Predicting pairwise Net Sales similarity with Portfolio Similarity

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<td></td>
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<td>0.066***</td>
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<tr>
<td></td>
<td>(23.50)</td>
<td>(21.72)</td>
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<tr>
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<td>-0.003**</td>
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<tr>
<td></td>
<td>(-2.40)</td>
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<td>0.011***</td>
<td>0.012***</td>
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<tr>
<td></td>
<td>(9.75)</td>
<td>(11.52)</td>
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<td>PSIFI_Pair</td>
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<td></td>
<td>(12.52)</td>
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<td>Big_Pair</td>
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<td></td>
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<td>(8.41)</td>
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<tr>
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<td></td>
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<td>R²</td>
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## RQ3: Net Sales similarity and Return Correlation – subsample publically traded companies

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<th>All</th>
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<th>PSIFI</th>
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<tr>
<td></td>
<td>(1)</td>
<td>(2)</td>
<td>(3)</td>
<td>(4)</td>
<td>(5)</td>
<td>(6)</td>
<td>(7)</td>
<td>(8)</td>
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<td>RetCorr_pair</td>
<td>0.005</td>
<td>0.003</td>
<td>-0.015*</td>
<td>0.029</td>
<td>0.029**</td>
<td>0.035***</td>
<td>0.030***</td>
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<tr>
<td></td>
<td>(0.64)</td>
<td>(0.40)</td>
<td>(-1.68)</td>
<td>(1.13)</td>
<td>(2.17)</td>
<td>(3.65)</td>
<td>(3.91)</td>
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<td>0.978***</td>
<td>0.064**</td>
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<td></td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(9.75)</td>
<td>(9.14)</td>
<td>(2.60)</td>
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<td>0.558***</td>
<td>0.513***</td>
<td>0.634***</td>
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<td></td>
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<td>(28.68)</td>
<td>(19.89)</td>
<td>(14.72)</td>
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<td>-0.002</td>
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<td>0.006</td>
<td>-0.009***</td>
<td>-0.009***</td>
<td>0.049***</td>
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<tr>
<td></td>
<td>(3.52)</td>
<td>(0.65)</td>
<td>(-0.46)</td>
<td>(-0.26)</td>
<td>(1.66)</td>
<td>(-3.06)</td>
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<td>0.028***</td>
<td>0.024***</td>
<td>0.023***</td>
<td>-0.127***</td>
<td>-0.021***</td>
<td>-0.001</td>
<td>-0.004</td>
<td>0.025</td>
</tr>
<tr>
<td></td>
<td>(4.52)</td>
<td>(3.83)</td>
<td>(3.42)</td>
<td>(-4.07)</td>
<td>(-4.80)</td>
<td>(-1.15)</td>
<td>(-1.02)</td>
<td>(1.33)</td>
</tr>
<tr>
<td>PSIFI_Pair</td>
<td>0.033***</td>
<td>0.029***</td>
<td>-0.017***</td>
<td></td>
<td>0.054***</td>
<td>0.047***</td>
<td></td>
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</tr>
<tr>
<td></td>
<td>(8.34)</td>
<td>(5.70)</td>
<td>(8.36)</td>
<td></td>
<td>(7.77)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Non-PSIFI_Pair</td>
<td>-0.021***</td>
<td>-0.024***</td>
<td>-0.017***</td>
<td></td>
<td>-0.028***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-8.96)</td>
<td>(-9.31)</td>
<td>(-6.31)</td>
<td></td>
<td>(-12.50)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Big_Pair</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.011***</td>
<td>0.024***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(2.97)</td>
<td>(8.01)</td>
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</tr>
<tr>
<td>Small_Pair</td>
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<td></td>
<td></td>
<td></td>
<td>-0.012***</td>
<td>-0.025***</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-2.00)</td>
<td>(-9.10)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conc_Pair_S</td>
<td>-0.014***</td>
<td>-0.014***</td>
<td>-0.011***</td>
<td></td>
<td>0.009</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-4.61)</td>
<td>(-4.68)</td>
<td>(-3.09)</td>
<td></td>
<td>(0.52)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>NonConc_Pair_S</td>
<td>0.015***</td>
<td>0.006*</td>
<td>0.001</td>
<td></td>
<td>0.034***</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.31)</td>
<td>(1.94)</td>
<td>(0.30)</td>
<td></td>
<td>(3.65)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Conc_Pair_I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.001</td>
<td>-0.009</td>
<td>0.006</td>
<td>-0.019***</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(0.51)</td>
<td>(-0.70)</td>
<td>(1.53)</td>
<td>(-3.87)</td>
</tr>
<tr>
<td>NonConc_Pair_I</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>-0.000</td>
<td>-0.026***</td>
<td>-0.030***</td>
<td>-0.021*</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>(-0.14)</td>
<td>(-7.22)</td>
<td>(-8.99)</td>
<td>(-1.95)</td>
</tr>
<tr>
<td>Constant</td>
<td>0.145***</td>
<td>0.112***</td>
<td>0.090***</td>
<td>0.090***</td>
<td>0.072***</td>
<td>0.014***</td>
<td>-0.008*</td>
<td>-0.006</td>
</tr>
<tr>
<td></td>
<td>(47.86)</td>
<td>(25.52)</td>
<td>(18.33)</td>
<td>(4.12)</td>
<td>(21.86)</td>
<td>(4.10)</td>
<td>(-1.93)</td>
<td>(-0.29)</td>
</tr>
<tr>
<td>Year FE</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Observations</td>
<td>65,595</td>
<td>65,595</td>
<td>29,403</td>
<td>6,832</td>
<td>70,139</td>
<td>70,139</td>
<td>31,842</td>
<td>7,096</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.022</td>
<td>0.026</td>
<td>0.018</td>
<td>0.057</td>
<td>0.029</td>
<td>0.193</td>
<td>0.208</td>
<td>0.192</td>
</tr>
</tbody>
</table>
RQ4: Sales similarity /Liquidity/Downgrades/crisis

<table>
<thead>
<tr>
<th></th>
<th>Sector Similarity</th>
<th>Issuer Level Similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>All (1)</td>
<td>Non-PSIFI (2)</td>
</tr>
<tr>
<td>Similarity_S_Illiquid</td>
<td>0.039***</td>
<td>0.037***</td>
</tr>
<tr>
<td></td>
<td>(27.72)</td>
<td>(22.06)</td>
</tr>
<tr>
<td>Similarity_S_Liquid</td>
<td>0.028***</td>
<td>0.026***</td>
</tr>
<tr>
<td></td>
<td>(16.66)</td>
<td>(13.01)</td>
</tr>
<tr>
<td>Similarity_L_Downgraded</td>
<td>-0.011*</td>
<td>-0.009*</td>
</tr>
<tr>
<td></td>
<td>(-3.05)</td>
<td>(-2.57)</td>
</tr>
<tr>
<td>Similarity_L_NotDowngraded</td>
<td>0.011</td>
<td>0.011</td>
</tr>
<tr>
<td></td>
<td>(1.93)</td>
<td>(1.88)</td>
</tr>
<tr>
<td>Similarity_S_Illiquid*Crisis</td>
<td>0.019***</td>
<td>0.019***</td>
</tr>
<tr>
<td></td>
<td>(7.61)</td>
<td>(6.81)</td>
</tr>
<tr>
<td>Similarity_L_Downgraded*Crisis</td>
<td>0.010</td>
<td>0.018</td>
</tr>
<tr>
<td></td>
<td>(1.94)</td>
<td>(1.22)</td>
</tr>
<tr>
<td>Similarity_L_NotDowngraded*Crisis</td>
<td>-0.014***</td>
<td>-0.011***</td>
</tr>
<tr>
<td></td>
<td>(-2.401)</td>
<td>(-1.474)</td>
</tr>
<tr>
<td>Similarity_S_Illiquid*Post-Crisis</td>
<td>0.008**</td>
<td>0.007*</td>
</tr>
<tr>
<td></td>
<td>(3.34)</td>
<td>(2.53)</td>
</tr>
<tr>
<td>Similarity_S_Liquid*Post-Crisis</td>
<td>0.021***</td>
<td>0.020**</td>
</tr>
<tr>
<td></td>
<td>(7.02)</td>
<td>(5.77)</td>
</tr>
<tr>
<td>Similarity_L_Downgraded*Post-Crisis</td>
<td>-0.011***</td>
<td>-0.007*</td>
</tr>
<tr>
<td></td>
<td>(-6.10)</td>
<td>(-2.95)</td>
</tr>
<tr>
<td>Similarity_L_NotDowngraded*Post-Crisis</td>
<td>-0.014***</td>
<td>-0.011***</td>
</tr>
<tr>
<td></td>
<td>(-2.401)</td>
<td>(-1.474)</td>
</tr>
</tbody>
</table>

Quarter FE: Y Y Y Y Y Y

N: 17,435,422 16,166,316 23,440 13,876,460 12,744,887 23,560

$R^2$: 0.011 0.0011 0.003 0.0112 0.113 0.203
RQ5: Common Sales in $ amount

- **Common Sales Pair**[a,b]: Minimum amount of $ sales between insurer a and b
- **Total Common Sales Insurer [a]**: Sum of Common Sales of company a and the rest of the insurance system

<table>
<thead>
<tr>
<th>Sales</th>
<th>Prudential</th>
<th>Metlife</th>
<th>AIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford</td>
<td>$25</td>
<td>$40</td>
<td>$10</td>
</tr>
<tr>
<td>GM</td>
<td>$50</td>
<td>$50</td>
<td>$0</td>
</tr>
<tr>
<td>Toyota</td>
<td>$25</td>
<td>$10</td>
<td>$90</td>
</tr>
<tr>
<td>Tot</td>
<td>$100</td>
<td>$100</td>
<td>$100</td>
</tr>
</tbody>
</table>

**Common sales=Min($i,$j)**

<table>
<thead>
<tr>
<th>Pru-Met</th>
<th>Pru-AIG</th>
<th>Met-Pru</th>
<th>Met-AIG</th>
<th>AIG-Pru</th>
<th>AIG-Met</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford</td>
<td>$25</td>
<td>$10</td>
<td>$25</td>
<td>$10</td>
<td>$10</td>
</tr>
<tr>
<td>GM</td>
<td>$50</td>
<td>$0</td>
<td>$50</td>
<td>$0</td>
<td>$0</td>
</tr>
<tr>
<td>Toyota</td>
<td>$10</td>
<td>$25</td>
<td>$10</td>
<td>$10</td>
<td>$25</td>
</tr>
<tr>
<td>Tot Pru</td>
<td>$85</td>
<td>$35</td>
<td>$120</td>
<td>$20</td>
<td>$105</td>
</tr>
</tbody>
</table>

- **Total Common Sales:**
  - Prudential: $120
  - Metlife: $105
  - AIG: $55
## Average Insurer Portfolio Similarity

<table>
<thead>
<tr>
<th>Holdings</th>
<th>Prudential</th>
<th>MetLife</th>
<th>AIG</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ford</td>
<td>50%</td>
<td>50%</td>
<td>0%</td>
</tr>
<tr>
<td>GM</td>
<td>25%</td>
<td>50%</td>
<td>0%</td>
</tr>
<tr>
<td>Toyota</td>
<td>25%</td>
<td>0%</td>
<td>100%</td>
</tr>
</tbody>
</table>

- Prudential and MetLife: 0.87
- Prudential and AIG: 0.41
- MetLife and AIG: 0

**Average Portfolio Similarity:**
- Prudential: 0.64
- MetLife: 0.44
- AIG: 0.21
RQ5: Predicting Insurers *Total Common Sales* with insurers *Average Portfolio Similarity*

<table>
<thead>
<tr>
<th>VARIABLES</th>
<th>(1)</th>
<th>(2)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Sector-level</td>
<td>Issuer-level</td>
</tr>
<tr>
<td></td>
<td>Ln(Total_Common_Sales)</td>
<td>Ln(Total_Common_Sales)</td>
</tr>
<tr>
<td>Avg_Similarity_S</td>
<td>1.204***</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(5.48)</td>
<td></td>
</tr>
<tr>
<td>Avg_Similarity_I</td>
<td></td>
<td>8.247***</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(22.20)</td>
</tr>
<tr>
<td>Ln(Size)</td>
<td>0.693***</td>
<td>0.814***</td>
</tr>
<tr>
<td></td>
<td>(44.13)</td>
<td>(50.38)</td>
</tr>
<tr>
<td>Concentration_S</td>
<td>-0.340</td>
<td></td>
</tr>
<tr>
<td></td>
<td>(-1.23)</td>
<td></td>
</tr>
<tr>
<td>Concentration_I</td>
<td></td>
<td>0.049</td>
</tr>
<tr>
<td></td>
<td></td>
<td>(0.04)</td>
</tr>
<tr>
<td>Avg_Business_similarity</td>
<td>-0.782***</td>
<td>-0.042</td>
</tr>
<tr>
<td></td>
<td>(-6.18)</td>
<td>(-0.31)</td>
</tr>
<tr>
<td>Constant</td>
<td>5.702***</td>
<td>1.691***</td>
</tr>
<tr>
<td></td>
<td>(16.10)</td>
<td>(4.71)</td>
</tr>
<tr>
<td>Quarter FE</td>
<td>Y</td>
<td>Y</td>
</tr>
<tr>
<td>Observations</td>
<td>3,395</td>
<td>3,454</td>
</tr>
<tr>
<td>R-squared</td>
<td>0.580</td>
<td>0.638</td>
</tr>
</tbody>
</table>

Robust t-statistics in parentheses

*** p<0.01, ** p<0.05, * p<0.1
Economic significance?

Delta Ln (Total_Common_Sales) = Beta*Delta Similarity
= Percentage of change in total common sales due to change in similarity

In previous example with Pru, Met, AIG = $ 93.3

<table>
<thead>
<tr>
<th></th>
<th>SECTOR-LEVEL</th>
<th>ISSUER-LEVEL</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average Total Common Sales</td>
<td>$2.8 billion</td>
<td>$1.8 billion</td>
</tr>
<tr>
<td>Std Dev (Average Sales Similarity)</td>
<td>0.108</td>
<td>0.073</td>
</tr>
<tr>
<td>Sensitivity (Beta)</td>
<td>1.204</td>
<td>8.247</td>
</tr>
<tr>
<td>Percentage Impact on Total Common sales if Average Sales Similarity increases by 1 std dev</td>
<td>(0.108x1.204) = 12.99%</td>
<td>(0.073x8.247) = 60.17%</td>
</tr>
<tr>
<td>Dollar Impact on Total Common sales if Average Sales Similarity increases by 1 std dev</td>
<td>12.99%x2.8 billion = $376 million</td>
<td>60.17%x1.8billion = $1.08 billion</td>
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</table>
Predicted Total_Common_Sales vs. Realized

<table>
<thead>
<tr>
<th></th>
<th>Ln(size)</th>
<th>Avg_Similarity_I</th>
<th>Concentration_I</th>
<th>Avg_Business_similarity</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSIFI</td>
<td>25.60997</td>
<td>0.129961</td>
<td>0.002553</td>
<td>0.7187399</td>
</tr>
<tr>
<td>AVG</td>
<td>21.99203</td>
<td>0.135214</td>
<td>0.03157</td>
<td>0.6046465</td>
</tr>
<tr>
<td>SMALL</td>
<td>13.4793</td>
<td>0.271771</td>
<td>0.428571</td>
<td>0.7089354</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th></th>
<th>Predicted Ln(Total_Common_Sales)</th>
<th>Predicted Total_Common_Sales</th>
<th>Realized Total_Common_Sales</th>
</tr>
</thead>
<tbody>
<tr>
<td>PSIFI</td>
<td>22.88604195</td>
<td>8,695,243,121</td>
<td>9,958,057,102</td>
</tr>
<tr>
<td>AVG</td>
<td>19.99057674</td>
<td>480,614,832</td>
<td>379,651,293</td>
</tr>
<tr>
<td>SMALL</td>
<td>14.18159542</td>
<td>1,442,078</td>
<td>74,914,110</td>
</tr>
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</table>
Thank You!