Too-Systemic-To-Fail
What Option Markets Imply About Sector-wide Government Guarantees

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Puzzling Crisis Facts: Missing Aggregate Tail Risk

• Crisis an episode of elevated systemic risk
• Correlations among financials increase sharply
• Financial sector crash insurance surprisingly cheap
  ◦ Financial index puts vs. individual bank OTM puts
    \[ r_{bank} = r_{index} + \epsilon_{bank} \]
• Specific to financial sector puts
• Alternative explanations
  1. Changes in risk + standard model
  2. Mispricing
  3. Counterparty risk
  4. Illiquidity
A Bailout Guarantee?

- Evidence: financial index puts cheap due to collective bailout guarantee for financial sector
- Model without bailout can’t match facts
- Model with bailout can
- Highly sensitive to government announcements

How Does it Work?

\[ r_{bank} = r_{index} + \epsilon_{bank} \]

- Government truncates sector-wide tail risk
- But does not eliminate any idiosyncratic tail risk

Crisis \Rightarrow \text{Aggregate risk} \uparrow \Rightarrow \begin{cases} 
\cdot \text{Puts on } r_{bank} \text{ and } r_{index} \text{ diverge} \\
\cdot \text{Return correlation } \uparrow : \text{more common variation over non-truncated region} 
\end{cases}
Basket-Index Put Spread

1. Insuring the index: \( \max (0, K - S^{\text{index}}) \)
2. Insuring each bank: \( \sum_i x_i \max (0, K - S^i) \) “the basket”

If \textit{aligned*}, then the basket-index OTM put spread informative about:

1. Degree of underlying idiosyncratic vs. systematic risk
2. Government guarantees that potentially affect this risk

\[
\text{cost per dollar insured} = \frac{\text{cost of insurance}}{\$ \text{ amount insured}}
\]

\[
\text{basket-index spread} = \text{cpdi}_{\text{basket}} - \text{cpdi}_{\text{index}}
\]

*Align: Moneyness, time-to-maturity, and total amount insured
Data: Options on ETFs (1999-2009)

- Exchange-traded options (CBOE) on 9 iShares sector ETFs and on the S&P 500 ETF
  - Nine sector ETFs, no overlap, span S&P 500
  - Financial sector ETF: ~90 banks, insurers
- Focus on 365 day $TTM$ and $|\Delta| = 20$, similar across moneyness and maturity
- OptionMetrics Vol Surface, raw options for robustness
Basket-Index Put Spread

*Moneyness $|\Delta| = 20$ for individual and index options; $TTM = 365$ days.
*Non-financial series is a value-weighted average
Basket-Index Spreads: Summary Statistics

Table: Basket-Index Spreads $|\Delta| = 20$, $TTM = 365$

<table>
<thead>
<tr>
<th></th>
<th>Financials</th>
<th></th>
<th>Non-financials</th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Puts</td>
<td>Calls</td>
<td>Puts</td>
<td>Calls</td>
</tr>
<tr>
<td>Pre-Crisis</td>
<td>mean</td>
<td>1.71</td>
<td>0.95</td>
<td>2.26</td>
</tr>
<tr>
<td>(Jan 03-Jul 07)</td>
<td>max</td>
<td>3.76</td>
<td>5.10</td>
<td>9.65</td>
</tr>
<tr>
<td>Crisis</td>
<td>mean</td>
<td>5.85</td>
<td>1.08</td>
<td>3.70</td>
</tr>
<tr>
<td>(Aug 07-Jun 09)</td>
<td>max</td>
<td>15.87</td>
<td>1.27</td>
<td>7.58</td>
</tr>
</tbody>
</table>

- $diff^2$: crisis – pre-crisis & financials – non-financials: $+2.70$ (mean), $+14.18$ (max)
Black-Scholes Basket-Index Spread

- One-factor model for log returns:
  \[ r_{\text{bank}} = \mu + \lambda r_{\text{index}} + \epsilon \]

  - Compute the BS value:
    \[
    \text{Put}^{\text{BS,index}}_F = \text{BS}(\sigma_{\text{index}}, K, r_f, T)
    \]
    \[
    \text{Put}^{\text{BS,basket}}_F = \text{BS}(\sigma_{\text{bank}}, K, r_f, T)
    \]

  - Feed in index implied vol and realized correlation to back out individual vol:
    \[
    \sigma^2_{t,\text{index}} = \frac{N_t + N_t(N_t - 1)\rho_t}{N_t^2} \sigma^2_{t,\text{bank}}.
    \]

  - Impose symmetry: \( N_t = \left( \sum_i \omega^2_t \right)^{-1} \)

- BS cost per dollar insured for basket versus index:
  \[
  \frac{\text{Put}^{\text{BS,basket}}_F}{K} - \frac{\text{Put}^{\text{BS,index}}_F}{K}
  \]
Basket-Index Spreads for Financials

<table>
<thead>
<tr>
<th></th>
<th>BS</th>
<th>data</th>
<th>data-BS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Crisis mean</td>
<td>3.06</td>
<td>1.71</td>
<td>-1.34</td>
</tr>
<tr>
<td>Pre-Crisis max</td>
<td>6.37</td>
<td>3.76</td>
<td>1.47</td>
</tr>
<tr>
<td>Crisis mean</td>
<td>4.03</td>
<td>5.86</td>
<td>1.83</td>
</tr>
<tr>
<td>Crisis max</td>
<td>8.08</td>
<td>15.87</td>
<td>9.30</td>
</tr>
</tbody>
</table>

* Basket-Index Spreads $|\Delta| = 20, TTM = 365

Financials

- Pre-crisis: index options expensive relative to basket (-1.34)
- Crisis: index options cheap relative to basket (+1.83)
- $diff^2$: crisis – pre-crisis & data – BS: +3.17 (mean) +7.83 (max)

Non-financials

- Crisis: index options remain expensive relative to basket (-0.47)
- $diff^2$: crisis - pre-crisis, Data - B-S: +1.59 (mean), +3.77 (max)
**Bailout Model**

- One-factor model for log returns:

\[ r^{\text{bank}} = \mu + \lambda r^{\text{index}} + \epsilon. \]

- Government announces bailout rule:

\[ r^{\text{index}} = \min(\tilde{r}, r), \quad \tilde{r} \sim \mathcal{N}(0, \delta_r^2). \]

- Compute the BS value:

\[
\begin{align*}
\text{Put}_{F}^{\text{Bail, index}} &= BS^{\text{Bail}}(\sigma_{\text{index}}, K, r_f, T, \mu, \rho) \\
\text{Put}_{F}^{\text{Bail, basket}} &= BS^{\text{Bail}}(\sigma_{\text{bank}}, K, r_f, T, \mu, \rho)
\end{align*}
\]

- Cost per dollar insured for basket versus index:

\[
\frac{\text{Put}_{F}^{\text{Bail, basket}}}{K} - \frac{\text{Put}_{F}^{\text{Bail, index}}}{K}
\]
Basket-Index Spread With Bailout

<table>
<thead>
<tr>
<th></th>
<th>Data minus BS</th>
<th>Bailout $r = 0.60$</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>minus BS</td>
</tr>
<tr>
<td>Pre-Crisis</td>
<td>mean</td>
<td>-1.34</td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>1.47</td>
</tr>
<tr>
<td>Crisis</td>
<td>mean</td>
<td>1.83</td>
</tr>
<tr>
<td></td>
<td>max</td>
<td>9.30</td>
</tr>
</tbody>
</table>

* Basket-Index Spreads $|\Delta| = 20, TTM = 365
Guarantee and Implied Volatility Skew: Hypothesis

Put Implied Volatility

- Fin. Index
- Fin. Basket
- Fin. Basket Minus Index

Moneyness ($\Delta$)
Guarantee and Implied Volatility Skew: Hypothesis

Put Implied Volatility

- Fin. Index
- Fin. Basket
- Fin. Basket Minus Index
- Fin. Index: Bailout
- Fin. Basket: Bailout
- Fin. Basket Minus Index: Bailout
Implied Volatility Skew for Puts: Basket Minus Index

Put Implied Volatility: Basket Minus Index

- **Fin. Pre–Crisis**
- **Non–Fin. Pre–Crisis**
- **Fin. Crisis**
- **Non–Fin. Crisis**

Moneyness (|Δ|)
Announcement Effects

Six “positive” events that ex-ante suggest increased likelihood/size of bailout, e.g.
- 07/11/2008: Paulson announces bailout plan for Fannie and Freddie
- 10/3/2008: Revised bailout plan (TARP) passes the U.S. House

Subsequent 5 day average spread increase:
- (data – BS, financials – non-financials): 1.27 cents or 40%
- (data – BS): 1.64 cents or 64%

Six “negative” events, e.g.
- 03/3/2008: Bear Stearns is bought for $2 per share
- 09/29/2008: House votes no on the bailout plan

Subsequent 5 day average spread decrease:
- (data – BS, financials – non-financials): 0.91 cents or 28%
- (data – BS): 1.92 cents or 23%
Alternative Explanations

Counterparty Risk

- Marked-to-market daily (margin: market val plus 2-day cushion)
- (Percentage) effect should be larger on short-dated options
- Exchange-traded, guaranteed by the OCC
- Announcement effects should have opposite effect

Mispricing

- Arbitrage involves less capital (vs. CDS basis or TIPS-Treasuries trades)
- Short sale ban was shortlived
- Hedging costs would suggest weaker effect for deep OTM versus ATM options

Liquidity

- Financial index options more liquid than other sectors
- Differential liquidity between individual and index options smaller in financial sector
- No differential liquidity between puts and calls
Summary

• Normally, catastrophe insurance (OTM financial index put) is relatively expensive

• During crisis became cheap (flattened implied vol skew)

• Other facts:
  ◇ Next biggest put spread: Consumer discretionary (autos)
  ◇ Large bank puts much cheaper than small banks (too-big-to-fail)

• Evidence of “too-systemic-to-fail” government guarantee

• Why does this matter?
  ◇ Policy effects: Debt bailout implies prop-up of financial sector equity
  ◇ Guidance for systemic risk measurement

• Structural model suggests that 50% of the equity value of the U.S. financial sector was due to collective bailout guarantee
## Basket-Index Put Spreads: Other Sectors

<table>
<thead>
<tr>
<th>Sector</th>
<th>Full Sample</th>
<th>Pre-Crisis</th>
<th>Crisis</th>
<th>Crisis – Pre-Crisis</th>
</tr>
</thead>
<tbody>
<tr>
<td>Financials</td>
<td>mean 2.94</td>
<td>1.71</td>
<td>5.86</td>
<td>4.15</td>
</tr>
<tr>
<td></td>
<td>max 15.87</td>
<td>3.76</td>
<td>15.87</td>
<td>12.11</td>
</tr>
<tr>
<td>Consumer Disc.</td>
<td>mean 3.58</td>
<td>2.92</td>
<td>5.12</td>
<td>2.20</td>
</tr>
<tr>
<td></td>
<td>max 12.40</td>
<td>6.35</td>
<td>12.40</td>
<td>6.05</td>
</tr>
<tr>
<td>Materials</td>
<td>mean 3.04</td>
<td>2.28</td>
<td>4.84</td>
<td>2.57</td>
</tr>
<tr>
<td></td>
<td>max 10.34</td>
<td>4.54</td>
<td>10.34</td>
<td>5.80</td>
</tr>
<tr>
<td>Technology</td>
<td>mean 3.30</td>
<td>2.89</td>
<td>4.27</td>
<td>1.38</td>
</tr>
<tr>
<td></td>
<td>max 9.54</td>
<td>6.27</td>
<td>9.54</td>
<td>3.27</td>
</tr>
<tr>
<td>Healthcare</td>
<td>mean 2.52</td>
<td>2.02</td>
<td>3.69</td>
<td>1.67</td>
</tr>
<tr>
<td></td>
<td>max 8.59</td>
<td>5.33</td>
<td>8.59</td>
<td>3.26</td>
</tr>
<tr>
<td>Industrials</td>
<td>mean 2.90</td>
<td>2.62</td>
<td>3.57</td>
<td>0.95</td>
</tr>
<tr>
<td></td>
<td>max 7.04</td>
<td>5.17</td>
<td>7.04</td>
<td>1.87</td>
</tr>
<tr>
<td>Consumer Staples</td>
<td>mean 2.28</td>
<td>1.96</td>
<td>3.05</td>
<td>1.09</td>
</tr>
<tr>
<td></td>
<td>max 7.90</td>
<td>3.82</td>
<td>7.90</td>
<td>4.08</td>
</tr>
<tr>
<td>Utilities</td>
<td>mean 1.87</td>
<td>1.55</td>
<td>2.63</td>
<td>1.08</td>
</tr>
<tr>
<td></td>
<td>max 6.79</td>
<td>3.90</td>
<td>6.79</td>
<td>2.89</td>
</tr>
<tr>
<td>Energy</td>
<td>mean 1.99</td>
<td>1.79</td>
<td>2.46</td>
<td>0.67</td>
</tr>
<tr>
<td></td>
<td>max 5.74</td>
<td>5.35</td>
<td>5.74</td>
<td>0.39</td>
</tr>
</tbody>
</table>
Too-Big-to-Fail?
Put Prices of Largest Banks (differenced versus Black-Scholes)

Table: Volatility-Adjusted Put Prices ($\Delta = 20$, $TTM = 365$)

<table>
<thead>
<tr>
<th></th>
<th>Basket</th>
<th>Big 12</th>
<th>C</th>
<th>AIG</th>
<th>BoA</th>
<th>JP</th>
<th>Wells</th>
<th>Wach</th>
<th>GS</th>
<th>Amex</th>
<th>MS</th>
<th>Mer</th>
<th>Fan</th>
<th>Fred</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Crisis mean</td>
<td>0.20</td>
<td>-0.16</td>
<td>-0.02</td>
<td>0.77</td>
<td>-0.95</td>
<td>-0.58</td>
<td>1.08</td>
<td>0.24</td>
<td>-0.34</td>
<td>-0.07</td>
<td>-1.08</td>
<td>-0.38</td>
<td>-0.57</td>
<td>0.02</td>
</tr>
<tr>
<td></td>
<td>3.70</td>
<td>2.89</td>
<td>2.26</td>
<td>3.04</td>
<td>4.21</td>
<td>3.32</td>
<td>3.16</td>
<td>3.21</td>
<td>1.69</td>
<td>2.42</td>
<td>2.37</td>
<td>2.27</td>
<td>3.11</td>
<td>3.61</td>
</tr>
<tr>
<td>Crisis mean</td>
<td>1.69</td>
<td>-1.11</td>
<td>-0.92</td>
<td>-0.59</td>
<td>-3.70</td>
<td>-0.49</td>
<td>-0.10</td>
<td>-5.35</td>
<td>-0.48</td>
<td>1.79</td>
<td>-4.60</td>
<td>-1.05</td>
<td>0.63</td>
<td>1.51</td>
</tr>
<tr>
<td></td>
<td>13.58</td>
<td>19.49</td>
<td>27.71</td>
<td>18.38</td>
<td>41.78</td>
<td>14.00</td>
<td>15.39</td>
<td>13.49</td>
<td>17.48</td>
<td>18.84</td>
<td>25.77</td>
<td>9.12</td>
<td>12.88</td>
<td>19.10</td>
</tr>
</tbody>
</table>
Bailout-adjusted Basket-Index Spreads: Actual Minus Black Scholes.
# Implied Correlations

**Table:** Implied Correlation, $|\Delta| = 20$, $TTM = 365$

<table>
<thead>
<tr>
<th></th>
<th>Puts</th>
<th>Puts min Calls</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Crisis mean</td>
<td>IC</td>
<td>IC-RC</td>
</tr>
<tr>
<td></td>
<td>0.69</td>
<td>0.23</td>
</tr>
<tr>
<td>Crisis mean</td>
<td>0.65</td>
<td>0.00</td>
</tr>
</tbody>
</table>

The implied correlation is chosen such that the B-S basket-index spread matches the actual spread.

- Put implied correlation falls for F, rises for NF
- Correlation risk premium falls much more for F than for NF; F puts become cheap rel. to NF
- F puts become cheap also relative to calls
Put Spread Around Announcement Dates: $\text{diff}^2$