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

B. Kelly    H. Lustig    S. Van Nieuwerburgh
Chicago Booth    UCLA Anderson    NYU Stern

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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?

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

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

Crisis ⇒ Aggregate risk \(\uparrow\) ⇒
- Puts on \(r_{\text{bank}}\) and \(r_{\text{index}}\) diverge
- Return correlation \(\uparrow\): more common variation over non-truncated region
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 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: $\sim$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.
Financial vs. Non-financial Basket-Index Put Spread

* 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>1.71</td>
<td>0.95</td>
<td>2.26</td>
<td>1.90</td>
</tr>
<tr>
<td>(Jan 03-Jul 07)</td>
<td>3.76</td>
<td>5.10</td>
<td>9.65</td>
<td>4.57</td>
</tr>
<tr>
<td>Crisis</td>
<td>5.85</td>
<td>1.08</td>
<td>3.70</td>
<td>2.31</td>
</tr>
<tr>
<td>(Aug 07-Jun 09)</td>
<td>15.87</td>
<td>1.27</td>
<td>7.58</td>
<td>2.75</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:
    \[ \text{Put}_{F}^{\text{BS, index}} = BS(\sigma^{\text{index}}, K, r_{f}, T) \]
    \[ \text{Put}_{F}^{\text{BS, basket}} = BS(\sigma^{\text{bank}}, K, r_{f}, T) \]

  - Feed in index implied vol and realized correlation to back out individual vol:
    \[ \sigma_{t, \text{index}}^{2} = \frac{N_{t} + N_{t}(N_{t} - 1)\rho_{t}}{N_{t}^{2}} \sigma_{t, \text{bank}}^{2} \cdot \]

  - Impose symmetry: \( N_{t} = (\sum_{i} \omega_{t}^{2})^{-1} \)

- BS cost per dollar insured for basket versus index:
  \[ \frac{\text{Put}_{F}^{\text{BS, basket}}}{K} - \frac{\text{Put}_{F}^{\text{BS, index}}}{K} \]
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</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>3.06</td>
<td>1.71</td>
<td>-1.34</td>
</tr>
<tr>
<td>max</td>
<td>6.37</td>
<td>3.76</td>
<td>1.47</td>
</tr>
<tr>
<td>Crisis</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>4.03</td>
<td>5.86</td>
<td>1.83</td>
</tr>
<tr>
<td>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 $r = 0.60$ minus BS</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pre-Crisis</td>
<td></td>
<td></td>
</tr>
<tr>
<td>mean</td>
<td>-1.34</td>
<td>-0.01</td>
</tr>
<tr>
<td>max</td>
<td>1.47</td>
<td>0.01</td>
</tr>
<tr>
<td>Crisis</td>
<td>1.83</td>
<td>1.58</td>
</tr>
<tr>
<td>mean</td>
<td></td>
<td></td>
</tr>
<tr>
<td>max</td>
<td>9.30</td>
<td>8.44</td>
</tr>
</tbody>
</table>

* Basket-Index Spreads $|\Delta| = 20, $TTM = 365*
Bailout-adjusted Basket-Index Spreads: Actual Minus Black Scholes.
Guarantee and Implied Volatility Skew: Hypothesis

Put Implied Volatility

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

Moneyness (|∆|)

0 10 20 30 40 50 60

20 25 30 35 40 45 50
 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

Moneyness (|\Delta|)

0 10 20 30 40 50 60

20 25 30 35 40 45 50 55

0 10 20 30 40 50 60

Moneyness (|\Delta|)
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
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%
Put Spread Around Announcement Dates: $diff^2$

Positive Announcements

Negative Announcements
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