“Near-Coincident” Indicators of Systemic Stress

CAFIN Workshop

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International Monetary Fund
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Main Takeaways

- Finding good indicators of systemic stress is hard, in part because determining the benchmark against which to test them is hard.

- Market price-based measures usually “peak” at nearly the same time as severe stress (tail events)—hence the title “near-coincident.”

- However, this does not imply such measures are completely useless—early trend changes or thresholds can still be found.
Main Takeaways

- Some less complicated measures do “better” than sophisticated ones.
- Usefulness of measure varies with type of crisis – e.g., some can point to “causes” of systemic stress.
- Measures can be used for purposes other than early warning (e.g., when to deploy macroprudential tools or when to exit).
- Points to need for more research into what constitutes truly “early” warnings.
Motivations

- G-20 Information Gaps Initiative—asked us (FSB/BIS/IMF) to develop standard measures of tail risk (systemic risk).
  - “Coincident” measures of tail events.
- Clear need to develop near-term indicators—to flag crisis that is about to materialize.
  - Use of macroprudential tools and crisis management techniques (e.g., time to release buffers and/or provide liquidity).
  - Possible that “near-coincident” indicators could that help predict the tail events.
In Context

What the Paper Does

- Develops a “coincident” indicator of systemic stress (a benchmark).
- Tests 11 “near-coincident” indicators for their ability to predict these tail events and recognizes:
  - The important role of high-frequency market-based indicators
  - That these indicators are likely to flag imminent crisis within a year
  - That some indicators designed for purposes other than early warning
- Delves into measures of interconnectedness (not covered today).
Tests for ‘Early Warning’

Three tests:

1. Ability to forecast systemic financial stress at a reasonable horizon.
   - Granger Causality at various horizons
   - OLS regressions

2. Ability to predict extreme SFS with reasonable accuracy.
   - Logit model

3. Early turning point.
   - Quandt-Andrews breakpoint tests
A Coincident Indicator of Stress

- We call the benchmark “Systemic Financial Stress (SFS).”

- We construct it with the following data:
  - Daily equity returns of SIFIs within an economy
  - Daily stock-index (market) returns
  - January 2003 – April 2011
  - US: 17 Financial Institutions; S&P500 returns
  - Euro Area: 19 FIs; country-level market returns
The SFS — What is it?

- Event: Fraction of US financial institutions experiencing large and persistent negative abnormal returns.
- ‘Abnormal’ returns = Bank equity returns – S&P500 returns
- ‘Large’: Lower 5th percentile of abnormal returns
- ‘Persistent’: A day with large abnormal returns and cumulatively negative returns for the following two weeks
- Extreme SFS: SFS >= 0.25 (0-1 variable for when more than 25% of banks in distress)
Near-coincident Indicators

<table>
<thead>
<tr>
<th>Indicator</th>
<th>What is it?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Yield Curve slope</td>
<td>The difference between the yield on 10-year Treasury bonds and 3-month Treasury bills</td>
</tr>
<tr>
<td>Time-varying Conditional Value-at-Risk (CoVaR)</td>
<td>The value-at-risk of the financial system conditional on institutions being under distress.</td>
</tr>
<tr>
<td>Rolling CoVaR</td>
<td>The value at risk of the financial system conditional on institutions being under distress.</td>
</tr>
<tr>
<td>Joint Probability of Distress (JPoD)</td>
<td>Measures the joint probability of distress of all institutions by estimating a multivariate density from the data and modeling distress-dependence by the CIMDO-copula function</td>
</tr>
<tr>
<td>Credit Suisse Fear Barometer</td>
<td>Measures investor sentiment, and the number represented by the index prices zero-premium collars that expire in three months.</td>
</tr>
<tr>
<td>Distance to default (DD)</td>
<td>The number of standard deviations the banking system is away from the default point--at which the liabilities of the banks are just equal to the market value of assets.</td>
</tr>
<tr>
<td>Diebold-Yimaz (DY)</td>
<td>A time-varying measure of outward spillovers of all institutions.</td>
</tr>
<tr>
<td>VIX</td>
<td>Chicago Board Options Exchange Volatility Index calculated from S&amp;P 500 option prices.</td>
</tr>
<tr>
<td>LIBOR-Overnight Indexed Swap (OIS) spread</td>
<td>Measure of the risk of default associated with lending to other banks in the LIBOR market.</td>
</tr>
<tr>
<td>Systemic Liquidity Risk Indicator (SLRI)</td>
<td>Measures the breakdown of arbitrage conditions in major markets</td>
</tr>
<tr>
<td>Systemic Contingent Claims Approach (CCA)</td>
<td>Measures the joint dependence of various financial institutions during crisis</td>
</tr>
</tbody>
</table>
Near-coincident Indicator Types

**Balance sheet based**
- CoVaR
- Distance-to-default
- SCCA

**Equity-market based**
- VIX
- Credit Suisse Fear Barometer

**Macro / cross-market based**
- LIBOR-OIS spread
- Yield curve slope
- Systemic Liquidity Risk Indictor

**Debt-market based (CDS & bond spreads)**
- Diebold-Yilmaz
- JPoD
The Indicators and the SFS
The SFS and the VIX

VIX
(Risk indicator in percent, RHS)
## Test 1: Granger Causality

### Granger Causality of systemic risk measure to the event indicator

<table>
<thead>
<tr>
<th></th>
<th>p-Values for Granger Causality Tests with Various Lags 1/</th>
<th>Scores 2/</th>
<th>p-Values for t-Test at Each Lag 3/</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>52 weeks</td>
<td>26 weeks</td>
<td>4 weeks</td>
<td>1 week</td>
</tr>
<tr>
<td>Time-varying CoVaR</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>Diebold-Yilmaz</td>
<td>0.000</td>
<td>0.049</td>
<td>0.002</td>
<td>0.000</td>
</tr>
<tr>
<td>Libor-OIS spread</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
<tr>
<td>VIX</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
</tr>
</tbody>
</table>

Note: Black boldface values are significant at 1 percent level. Red boldface values are those with no two-way causality and significant at the 1 percent level.

### First sub-test score:
- GC tests with lag-lengths in each column—4 sets of VARs.
- P-values reported.
- **Red-bold:** No two-way causality, significant at 1 percent.
- Score: Fraction of red week-lags over total (83).

### Second sub-test score
- One OLS regression: SFS on lags of itself and each indicator.
- P-values for t-test on whether a particular lag is significant.
- Score: Fraction of significant weeks over total (83).
Test 1: Granger Causality Results

Predicting systemic stress

- Yield curve
- T-CoVaR
- Diebold-Yilmaz
- LIBOR-OIS
- VIX
- DD
- JPoD
- CSFB
- R-CoVaR
- SLRI
- SCCA

Test score vs Overall score
Test 2: Predicting Extreme Events

Forecastability of extreme events: logit regressions looking like GC tests

<table>
<thead>
<tr>
<th>Indicator</th>
<th>6 weeks (weight = 6)</th>
<th>4 weeks (weight = 2)</th>
<th>1 week (weight = 1)</th>
<th>p-Values for Sum of Lags of Indicators Equal to 0</th>
<th>Weighted average p-values</th>
<th>p-Value Score</th>
<th>McFadden R-squares</th>
<th>McFadden R2 Scores weighted avg F - H</th>
<th>Total Score average E and I</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-varying CoVaR</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>A</td>
<td>D</td>
<td>F</td>
<td>G</td>
<td>H</td>
<td>I</td>
</tr>
<tr>
<td>Diebold-Yilmaz</td>
<td>0.000</td>
<td>0.000</td>
<td>0.000</td>
<td>B</td>
<td>0.00 1.00</td>
<td>0.41</td>
<td>0.35</td>
<td>0.36</td>
<td>0.39</td>
</tr>
<tr>
<td>Libor-OIS spread</td>
<td>0.003</td>
<td>0.000</td>
<td>0.004</td>
<td>C</td>
<td>0.00 1.00</td>
<td>0.32</td>
<td>0.26</td>
<td>0.19</td>
<td>0.29</td>
</tr>
<tr>
<td>VIX</td>
<td>0.021</td>
<td>0.001</td>
<td>0.000</td>
<td>E=1-D</td>
<td>0.01 0.99</td>
<td>0.31</td>
<td>0.29</td>
<td>0.23</td>
<td>0.30</td>
</tr>
</tbody>
</table>

Note: Black boldface values are significant at 1 percent level.

(3.1) \( \text{Prob}(SFS_t \geq 0.25 \mid X, B) = \frac{e^{X'B}}{1 + e^{X'B}}; \) where \( X'B \equiv c + \beta_1 SFS_{t-1} + \rho_1 x_{t-1} \)

(3.2) \( \text{Prob}(SFS_t \geq 0.25 \mid X, B) = \frac{e^{X'B}}{1 + e^{X'B}}; \) where \( X'B \equiv c + \sum_{s=1...4} \beta_s SFS_{t-s} + \sum_{s=1...4} \rho_s x_{t-s} \)

(3.3) \( \text{Prob}(SFS_t \geq 0.25 \mid X, B) = \frac{e^{X'B}}{1 + e^{X'B}}; \) where \( X'B \equiv c + \sum_{s=1...6} \beta_s SFS_{t-s} + \sum_{s=1...6} \rho_s x_{t-s} \)

where \( x \) is the near-coincident indicator.
Test 2: Prediction—Results

Predicting extreme events

- Test score
- Overall score

<table>
<thead>
<tr>
<th>Method</th>
<th>Test Score</th>
<th>Overall Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>JPoD</td>
<td>0.8</td>
<td>0.6</td>
</tr>
<tr>
<td>T-CoVaR</td>
<td>0.7</td>
<td>0.5</td>
</tr>
<tr>
<td>DD</td>
<td>0.6</td>
<td>0.4</td>
</tr>
<tr>
<td>LIBOR-OIS</td>
<td>0.5</td>
<td>0.3</td>
</tr>
<tr>
<td>CSFB</td>
<td>0.4</td>
<td>0.2</td>
</tr>
<tr>
<td>Diebold-Yilmaz</td>
<td>0.3</td>
<td>0.1</td>
</tr>
<tr>
<td>VIX</td>
<td>0.2</td>
<td>0.1</td>
</tr>
<tr>
<td>SLRI</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>R-CoVaR</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>Yield curve</td>
<td>0.1</td>
<td>0.1</td>
</tr>
<tr>
<td>SCCA</td>
<td>0.1</td>
<td>0.1</td>
</tr>
</tbody>
</table>
Test 3: Quandt-Andrews BP test

Turning Points: Quandt-Andrews Test on Persistence and Level

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Break date</th>
<th>p-Value</th>
<th>Rank Score (higher the better)</th>
<th>Break date</th>
<th>p-Value</th>
<th>Rank Score (higher the better)</th>
<th>Total Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Time-varying CoVaR</td>
<td>6-Aug-2007</td>
<td>0.000</td>
<td>0.5</td>
<td>6-Aug-2007</td>
<td>0.000</td>
<td>0.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Diebold-Yilmaz</td>
<td>16-Jul-2007</td>
<td>0.000</td>
<td>0.8</td>
<td>16-Jul-2007</td>
<td>0.000</td>
<td>0.9</td>
<td>0.9</td>
</tr>
<tr>
<td>Libor-OIS spread</td>
<td>30-Jul-2007</td>
<td>0.000</td>
<td>0.7</td>
<td>6-Aug-2007</td>
<td>0.000</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>VIX</td>
<td>9-Jul-2007</td>
<td>0.008</td>
<td>0.9</td>
<td>23-Jul-2007</td>
<td>0.000</td>
<td>0.8</td>
<td>0.9</td>
</tr>
</tbody>
</table>

Note: Black boldface values are significant at 5 percent level.

- Most indicators moved little before the crisis.
- Week in which indicators moved from a tranquil mode to a more volatile mode.
- Autoregressive regressions (4 lags) estimated for each indicator.
- QABP (for unknown break date) on level and persistence of the AR regression.
- How far ahead of Bear-Stearns was the BP?

\[
(4) \, x_t = c + \sum_{s=1}^{4} \rho_s x_{t-s} + \varepsilon_t,
\]

where x is the near-coincident indicator.
## Test 3: Break Point Test—Results

### Early turning point

<table>
<thead>
<tr>
<th>Test Score</th>
<th>Overall Score</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diebold-Yilmaz</td>
<td>0.90</td>
</tr>
<tr>
<td>VIX</td>
<td>0.88</td>
</tr>
<tr>
<td>LIBOR-OIS</td>
<td>0.85</td>
</tr>
<tr>
<td>Yield curve</td>
<td>0.75</td>
</tr>
<tr>
<td>SCCA</td>
<td>0.65</td>
</tr>
<tr>
<td>SLRI</td>
<td>0.55</td>
</tr>
<tr>
<td>R-CoVaR</td>
<td>0.45</td>
</tr>
<tr>
<td>JPoD</td>
<td>0.35</td>
</tr>
<tr>
<td>CSFB</td>
<td>0.25</td>
</tr>
</tbody>
</table>
Overall Results—United States
Overall Results—Euro Area
Robustness—U.S. sample

- Extreme SFS threshold varied: 33% and 20%.
- Extreme value and probit regressions instead of logit for the second test (extreme events).
- (NEW) Early attempts with out-of-sample forecasts.
  - Static and dynamic for 3 indicators
Robustness—United States

The graph shows the range and baseline score of various models. The x-axis represents different models (Diebold-Yilmaz, T-CoVaR, DD, Yield curve, VIX, LIBOR-OIS, JPoD, SLRI, CSFB, R-CoVaR, SCCA) and the y-axis represents the baseline score ranging from 0.0 to 1.0.
Robustness—Euro Area

Range
Baseline score
Out-of-Sample Forecasts

- Rerun GC tests from end-2002 to end-2006.
- Use coefficients from GC tests to “forecast” using actual lagged values of the SFS (static) or one-step ahead forecasts (dynamic) for Jan 2007 to April 2011.
- Calculated RMSE for difference between actual and forecasted values using 3 indicator (so far):
  - LIBOR-OIS
  - VIX
  - Yield Spread
Static Out-of-Sample Forecasts
- Initial results suggest Libor-OIS has lowest RMSE in the post-sample period.

- Should test one-step ahead by re-estimating GC coefficients; only using information through end-2006.

- Should test other indicators.

- Not enough extreme systemic stress to forecast with Logit model.
Conclusions and Implications

- **Choice of Indicator**
  - T-CoVaR, Diebold-Yilmaz among best; JPoD good for extreme events; DD and VIX early turning point.
  - Simple ones (LIBOR-OIS) do pretty well.
  - Use wide range of indicators, do not rely on any one.

- **Indicator Thresholds**
  - Could use turning points from break point test to “turn on” macropru tools.
  - For instance, VIX: 18-24 for U.S. or 23-27 for euro area.
  - Could use subsequent “lower than threshold” values for exit or to “turn off” macropru tools.
Caveats

- **Other Uses of Indicators**
  - Indicators have various uses and all of them are tested for early warning even though not designed to be such.
  - Some indicators better for extreme moves (e.g., SLRI and JPoD).
  - Some indicators could use alternative data and be better at early warning (e.g., JPoD with LIBOR-OIS data rather than CDSs).
  - Some indicators better at measuring capital shortfalls (e.g., CCA) rather than distress per se.

- Need more out-of-sample testing.
Looking Forward

- Trade-offs for early warning indicators:
  - between complexity & efficiency
  - between precision and timing
  - absolute vs. relative vulnerabilities

- Operational constraints: data integrity and computational capabilities.

- Good, though, to try to measure effectiveness using common benchmark.

- Judgment is (still, always) MOST important.
Additional Slides
Test 1: GC test and OLS

First sub-test

1. \[ SFS_t = c + \sum_{s=1}^{52} \beta_s SFS_{t-s} + \sum_{s=1}^{52} \rho_s x_{t-s} + \epsilon_t, \]
2. \[ SFS_t = c + \sum_{s=1}^{26} \beta_s SFS_{t-s} + \sum_{s=1}^{26} \rho_s x_{t-s} + \epsilon_t, \]
3. \[ SFS_t = c + \sum_{s=1}^{4} \beta_s SFS_{t-s} + \sum_{s=1}^{4} \rho_s x_{t-s} + \epsilon_t, \]
4. \[ SFS_t = c + \sum_{s=1}^{1} \beta_s SFS_{t-s} + \sum_{s=1}^{1} \rho_s x_{t-s} + \epsilon_t, \]

where \( x \) is the near-coincident indicator.

Second sub-test

1. \[ SFS_t = c + \sum_{s=1,4,26,52} \beta_s SFS_{t-s} + \sum_{s=1,4,26,52} \rho_s x_{t-s} + \epsilon_t, \]

where \( x \) is the near-coincident indicator.
Test 2: Extreme Events

\begin{align*}
(3.1) \quad \text{Prob}(SFS_t \geq 0.25 \mid X, B) &= \frac{e^{XB}}{1 + e^{XB}}; \text{where } X'B \equiv c + \beta_1 SFS_{t-1} + \rho_1 x_{t-1} \\
(3.2) \quad \text{Prob}(SFS_t \geq 0.25 \mid X, B) &= \frac{e^{XB}}{1 + e^{XB}}; \text{where } X'B \equiv c + \sum_{s=1 \ldots 4} \beta_s SFS_{t-s} + \sum_{s=1 \ldots 4} \rho_s x_{t-s} \\
(3.3) \quad \text{Prob}(SFS_t \geq 0.25 \mid X, B) &= \frac{e^{XB}}{1 + e^{XB}}; \text{where } X'B \equiv c + \sum_{s=1 \ldots 6} \beta_s SFS_{t-s} + \sum_{s=1 \ldots 6} \rho_s x_{t-s}
\end{align*}

where \( x \) is the near-coincident indicator.
(4) \[ x_t = c + \sum_{s=1}^{4} \rho_s x_{t-s} + \varepsilon_t, \]
where \( x \) is the near-coincident indicator.