A Framework for Assessing the Systemic Risk of Major Financial Institutions

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Background

- Importance of financial stability
- Macro-prudential perspective: focus on the stability of the financial system as a whole
  - How to measure the systemic risk of a banking system?
  - How to assess the vulnerability of a banking system?

Related studies

- Measuring systemic risk
  - Balance sheet information: NPL, profitability, etc
  - Market data: CDS spreads (Avesani et al, 2006)
    - More timely
    - Forward-looking
- Vulnerability assessment: stress testing
  - CGFS (2000, 2005), Drehmann (2008a, 2008b)

Contributions of this paper

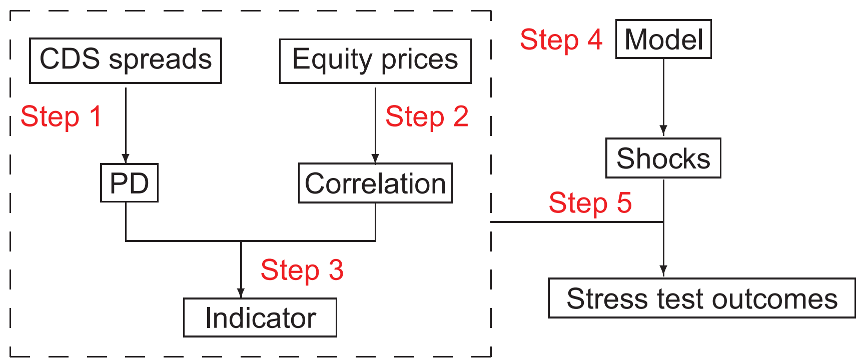
To propose a methodological framework with an illustrative example

- A new indicator of systemic risk: price of insurance against distressed losses
  - Based on market data: CDS and equity prices
  - Economically intuitive
  - Increase in both PD and correlations
- A novel approach to estimating / forecasting asset return correlations: high-frequency technique
- Vulnerability assessment: an integrated micro-macro model that allows for two-way linkages between the health of the banking system and the general economy

Outlines of the presentation

- Methodology
- Data
- An illustrative example
- Conclusion

Methodology: an overview



Methodology

- Step 1: estimating PDs from CDS spreads ($s_{i,t}$) (Duffie (1999) and Tarashev and Zhu (2008))

$$PD_{i,t} = \frac{a_t s_{i,t}}{a_t LGD_{i,t} + b_t s_{i,t}} \tag{1}$$

  - PDs are risk-neutral: physical PD + risk premium
  - PDs are forward-looking
- Step 2: estimating asset return correlations
  - Use equity return correlations as a proxy (Hull & White): short time horizon
  - Use the realized correlation based on high-frequency equity data
  - Use forecasted correlations

- Realized correlation: Barndorff-Nielsen & Shephard (2004)
  - Intraday equity return

$$r_{i,j} = p((i-1)h + \frac{hj}{M}) - p((i-1)h + \frac{h(j-1)}{M}), \quad j = 1, 2, ..., M. \quad (2)$$

  - Define realized correlation

$$\hat{\rho}_{(kl),j} = \frac{\sum_{j=1}^{M} r_{(k)j,i} r_{(l)j,i}}{\sqrt{\sum_{j=1}^{M} r_{(k)j,i}^2 \sum_{j=1}^{M} r_{(l)j,i}^2}} \quad (3)$$

  - Property: asymptotical convergence

$$\hat{\rho}_{(kl),j} \xrightarrow[\mathrm{M}\to\infty]{\mathrm{P}} \rho_{(kl),j} \quad (4)$$

- Major advantages of using realized correlations
  - A much more reliable estimate of correlation in the short-term (weekly time horizon): validity of the proxy correlation
  - Short-term realized correlations turn out to have significant and additional predicting power on future correlations

$$\rho_{t,t+12} = c + k_1 \rho_{t-12,t} + \sum_{i=1}^{I} k_{2i} \cdot \rho_{t-i,t-i+1} + \eta X_t + \nu_t \quad (5)$$

- Step 3: Construct an indicator of systemic risk
  - Price of insurance against distressed losses ("distress insurance premium")
  - A hypothetical weighted portfolio of debt instruments of all banks, weighted by bank liabilities
  - Monte Carlo simulation
    - Simulate (risk-neutral) portfolio loss distribution L
    - Indicator: $\sum_L L \cdot P(L)$ for all $L \geq L_0$.

- Alternative measures
  - nth-to-default probability: IMF
  - Credit VaR, expected shortfall
- Why using this indicator?
  - Economically meaningful: PDs are risk-neutral (alternative measures are more appropriate when physical PDs are used)
  - Desirable property: it increases in both PDs and correlations

- Step 4: stress testing model
  - A "macro" part: VAR analysis (X includes default risk parameters and financial market variables)

$$X_t = c_1 + \sum_{i=1}^{p} b_i \cdot X_{t-i} + \epsilon_t \qquad (6)$$

  - A "micro" part: determination of PDs of individual banks

$$PD_{i,t} = c_{2i} + a_i \cdot PD_{i,t-1} + \gamma X_t + \mu_{it} \qquad (7)$$

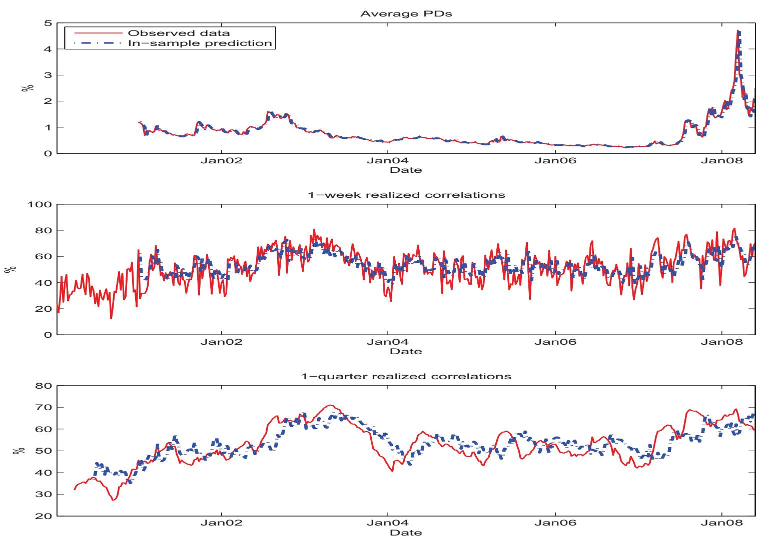
$$\rho_{t,t+12} = c + k_1 \rho_{t-12,t} + \sum_{i=1}^{l} k_{2i} \cdot \rho_{t-i,t-i+1} + \eta X_t + \nu_t \qquad (8)$$

  - The model allows for two-way linkages between the banking sector and the general market

- Step 5: stress testing exercise
  - Historical or hypothetical shock scenarios in VAR system (μ, ν, ϵ)
  - Feed into the model to affect individual PDs and forecasted correlations
  - Impact the indicator of systemic risk

Data

- 12 major financial institutions in the US
  - Bank of America, Bank of New York, Bear Stearns, Citi, Goldman Sachs, JPMorgan Chase, Lehman Brothers, Merrill Lynch, Morgan Stanley, State Street, Wachovia, Wells Fargo
- Sample period: January 2001 to May 2008
- CDS data: Markit
- Equity data: TAQ
- Macro-financial variables: fed fund rate, term spread, S&P500 return, VIX
- The time horizon of the indicator: one quarter


Average PDs
Observed data
In−sample prediction
%
Date
Jan02
Jan04
Jan06
Jan08
1−week realized correlations
1−quarter realized correlations

Empirical results

Table 1: Regression: forecasting correlations

	Regression 1	Regression 2	Regression 3
$\tilde{\rho}_{t-12,t}$	0.52**	0.63**	0.52**
$\tilde{\rho}_{t-1,t}$	0.18**		0.12**
FFR_t		-0.030	-0.026
$TERM_t$		-0.038	-0.033
SP500 ret_t		-0.0046**	-0.0036**
VIX_t		0.0015	0.0012
constant	0.19**	0.36**	0.33**
Adjusted R^2	0.54	0.55	0.56

- PDs, correlations transformed $[-\infty, +\infty]$
- X_t includes fed fund rate, term spread, S&P500 return, VIX

- Construct the indicator of systemic risk: price of insurance against distressed losses ($\geq$ 15% of total liabilities)
  - Tarashev and Zhu (2008): Monte Carlo simulation
  - Heterogeneous PD
  - Heterogeneous weight: size of bank liability
  - Random LGD: symmetric triangular distribution [0.1, 1]
  - LGD independent of PD

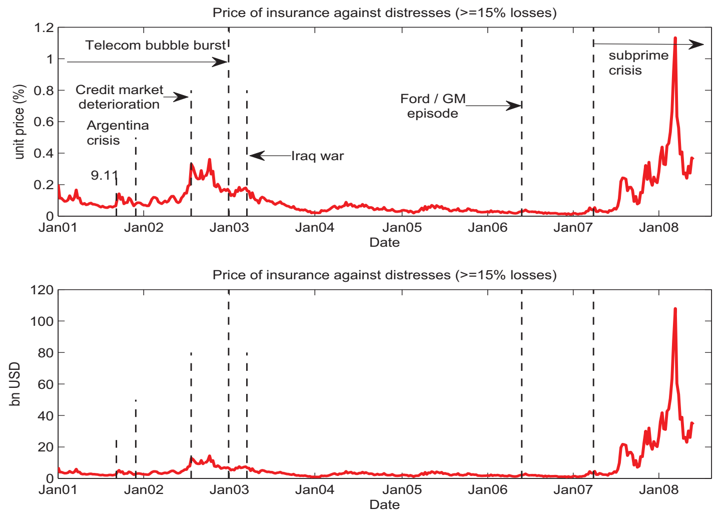

Price of insurance against distresses (>=15% losses)
unit price (%)
Telecom bubble burst
Credit market deterioration
Argentina crisis
9.11
Iraq war
Ford / GM episode
subprime crisis
Jan01
Jan02
Jan03
Jan04
Jan05
Jan06
Jan07
Jan08
Date
Price of insurance against distresses (>=15% losses)
bn USD
Date

Table 2: What determines the level of the indicator?

	Price of insurance	$n = 1$	$n = 2$	$n \geq 1$
PD_t	0.2077**	1.0994**	0.3085**	1.6952**
$\bar{\rho}_t$	0.0029**	-0.0204**	0.0008**	-0.0157**
constant	-0.0021**	0.0145**	-0.0005**	0.0110**
Adjusted R^2	0.97	0.96	0.99	0.99

"Macro" part of the model: VAR analysis

- Serial-correlated
- Financial factors affect PD and correlations
- The reverse impact is very weak

	$\tilde{PD}$	$\tilde{\rho}_W$	FFR	Term	SP500 ret	VIX
$\tilde{PD}$(-1)	0.98**	0.055**	-0.037*	0.033	-0.34	0.66*
$\tilde{\rho}_W$(-1)	0.083**	0.49**	-0.031	0.026	0.11	-0.22
FFR(-1)	0.010	-0.054**	0.94**	-0.012	-0.38	0.084
Term(-1)	0.012	-0.071**	-0.064**	0.97**	-0.47	0.097
SP500 ret(-1)	-0.0025**	-0.0029*	-0.00063	-0.00047	0.73**	0.0048
VIX(-1)	-0.00084	0.0012	-0.0011	0.0024	0.030	0.92**
Constant	-0.18	0.85**	0.14	0.20	-0.44	4.70
Adjusted R^2	0.97	0.43	0.99	0.99	0.53	0.91

"Micro" part of the model

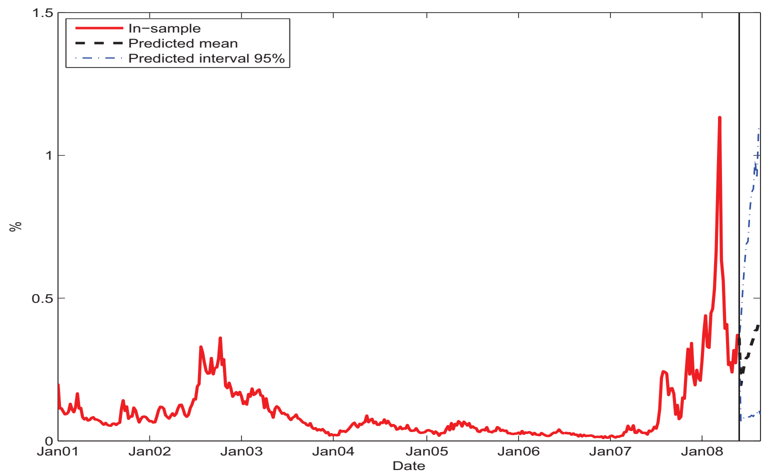
- Serial-correlated
- Positive effect of average PD
- Mixed effects of macro-financial factors

Factors	Bank 1	Bank 2	Bank 3	Bank 4	Bank 5	Bank 6
$\tilde{PD}_{i,t-1}$	0.70**	0.63**	0.68**	0.51**	0.38**	0.71**
$\tilde{PD}$	0.25**	0.39**	0.36**	0.63**	0.50**	0.23**
$\tilde{\rho}_W$	-0.04	-0.004	0.15**	0.01	0.11**	0.13**
FFR	-0.02	0.03**	0.10**	-0.03**	0.003	-0.03**
TERM	-0.02	0.04	0.08	-0.04	-0.01	-0.02*
SP500 ret	0.0004	-0.005**	-0.006**	-0.006**	0.001	-0.005**
VIX	0.0002	-0.003**	-0.004**	-0.004 **	0.002**	0.001
constant	-0.27	-0.09	-0.17	0.78**	-0.64**	-0.31**
Adj-R^2	0.92	0.98	0.98	0.98	0.97	0.97

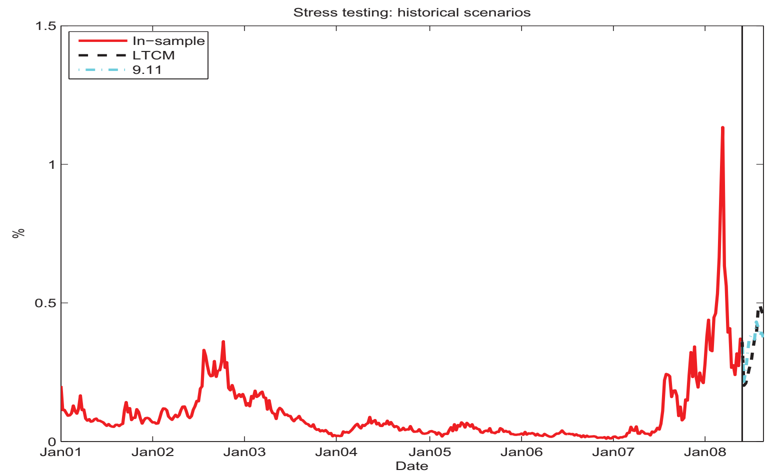
Factors	Bank 7	Bank 8	Bank 9	Bank 10	Bank 11	Bank 12
$\tilde{PD}_{i,t-1}$	0.45**	0.57**	0.38**	0.81**	0.79**	0.68**
$\tilde{PD}$	0.63**	0.50**	0.61**	0.10**	0.29**	0.35**
$\tilde{\rho}_W$	0.10**	0.15**	0.17**	0.02	0.03	0.05
FFR	0.08**	-0.02	-0.03**	-0.0003	0.02**	0.0000
TERM	0.05	-0.03	-0.06	0.01	0.01	0.02
SP500 ret	-0.003**	-0.004**	-0.001	0.002	-0.003**	-0.004**
VIX	-0.004**	-0.004**	-0.003**	0.004**	-0.003**	-0.004**
constant	0.27**	0.51**	0.20*	-0.57**	0.33**	0.006
Adj-R^2	0.99	0.98	0.97	0.91	0.98	0.97

Stress testing exercise

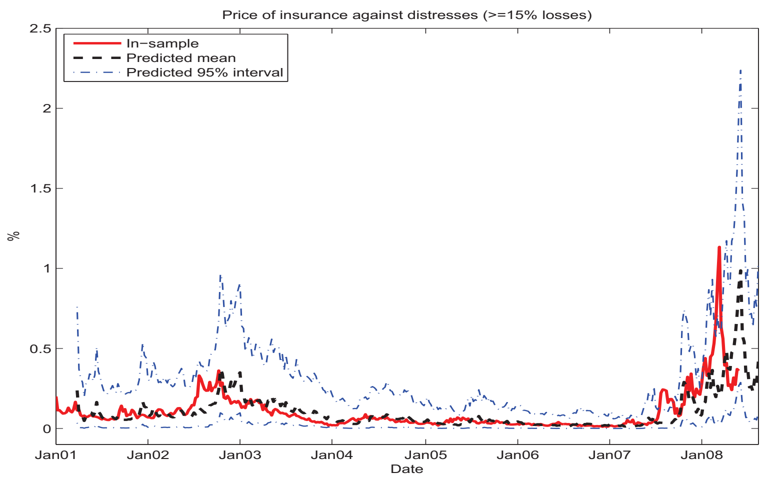
- Design stress-testing scenarios
  - Hypothetical shocks
  - Shocks fed into default risk parameters and affect the systemic risk indicator
- Exercise 1: statistical shocks
  - Use bootstrapping techniques, simulate (μ, ν, ϵ) N times $\rightarrow$ distribution of future systemic risk indicators


1.5
1
0.5
0
%
In−sample
Predicted mean
Predicted interval 95%
Jan01
Jan02
Jan03
Jan04
Jan05
Jan06
Jan07
Jan08
Date

- Exercise 2: historical scenarios – use shocks in macro-financial variables during major historical events



- The bootstrapping technique can also be used as a forecasting tool
  - The same exercise at each period in the sample
  - Plot the mean and distribution of 12-week-ahead systemic risk indicators
  - Results: located within the 95% confidence interval band most of the sample period, except the 2007.07-09 and 2008.03 (3.5% of sample weeks) → validation of the model used in the analysis


Price of insurance against distresses (>=15% losses)
In−sample
Predicted mean
Predicted 95% interval
%
2.5
2
1.5
1
0.5
0
Jan01
Jan02
Jan03
Jan04
Jan05
Jan06
Jan07
Jan08
Date

Summary

- The methodology intends to be general
- Only a first step toward improving our understanding of financial stability issues
  - Other dimensions to measure financial stability
  - Policy issues: how to prevent / deal with financial instability, interaction with monetary policies, etc