Measuring Systematic Risk

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European Banking Authority Policy Research Workshop
25 November 2014

Systematic versus Systemic

- Systematic risks are non-diversifiable risks that asset pricing theory predicts require compensation for investors to bear.
- Lars Hansen (2014) defines systemic risks as “risks of a breakdown or major dysfunction in financial markets.”*
- Since a major dysfunction in financial markets is surely non-diversifiable, systematic risk should include systemic risk.
- It may be difficult to differentiate systemic from other systematic risks: a shock to one sector of the economy (e.g., real estate) can generate, or coincide with, breakdowns of financial markets (e.g., MBS, SIVs holding MBS, and MBS-backed repos).

*“Challenges in Identifying and Measuring Systemic Risk” in M. Brunnermeier and A. Krishnamurthy eds., *Risk Topography: Systemic Risk and Macro Modeling*.

Appropriate Measures of Risk

- The intended use of a risk measure should determine its construction.
- If the objective is simply forecasting, such as predicting bankruptcy, then a risk measure based on a **physical** (actual or statistical) probability distribution may be appropriate.
- However, for many policymaking and bank regulatory objectives, a risk measure based on a **risk-neutral** distribution is appropriate.
- Risk-neutral probabilities discount physical probabilities of events by their relative **systematic risk** premia or marginal utilities.

Risk-Neutral Probabilities and Policymaking

- Narayana Kocherlakota argues that when a policymaker's decision results in random future losses to society, it should be based on the risk-neutral, not physical, probabilities of those losses.
- Doing so minimizes society's market value of losses.
- An example is monetary policy decisions to target inflation.
- I want to emphasize another argument for using risk-neutral probabilities in the context of bank regulation.
- Failure to base capital standards or deposit insurance premia on risk-neutral probabilities creates regulatory arbitrage opportunities whereby banks take excessive systematic risks.

* See "Optimal Outlooks" available at the website of the Federal Reserve Bank of Minneapolis.

Outline of Talk

1. A Simple Model of Bank Regulatory Arbitrage.
2. Evidence that Failure to Penalize Systematic Risk in Regulatory Standards Creates Moral Hazard.
3. Estimating Risk-Neutral Probabilities.
4. Systemic Risk Measures Using Risk-Neutral Probabilities.

Model of a Regulated Bank

- The following simple model explains the regulatory need to incorporate systematic risk by using risk-neutral probabilities.*
- It compares a bank's incentives when regulation is based on physical probabilities versus when it is based on risk-neutral probabilities.
- Failure to set regulatory capital or deposit insurance premia using risk-neutral probabilities gives the bank incentives to take excessive systematic risks.

*The model is based on G. Pennacchi (2006) "Deposit Insurance, Bank Regulation, and Financial System Risks," *Journal of Monetary Economics*.

Model Assumptions

1) A bank's initial deposits (debt) are normalized to equal 1.

2) The bank's initial equity capital equals k.

3) The bank invests $(1+k)$ in a portfolio of competitively-priced loans and securities whose return at the end of the period is

$$\begin{matrix}\text{Portfolio} \\ \text{Return}\end{matrix} = \begin{cases} R_L & \text{with probability } p \quad \text{(no loan default)} \\ d & \text{with probability } 1\text{-}p \quad \text{(loan default)} \end{cases}$$

4) Let R_F be the default-free return. To allow the possibility of bank failure, it is assumed that

$$d\left(1+k\right) < R_F < R_L\left(1+k\right)$$

The Equilibrium Rate on Uninsured Deposits

- If this bank issues **uninsured** deposits (debt), then the competitive promised return, R_D, is

$$R_D = R_L \left(1 - \frac{dk}{R_F - d} \right) + R_F \frac{dk}{R_F - d}$$

- R_D is a weighted average of the promised return on loans, R_L, and the default-free return, R_F.

- The weight on the default-free return is greater, the higher is the bank's capital ratio, k.

Fair Market Deposit Insurance and Capital Standards

- Now suppose that deposits are government-insured, so that depositors are paid the default-free return of R_F.
- At the end of the period, the insurer collects P_M if the bank does not default and pays $R_F - d(1+k)$ if the bank defaults.
- The fair market insurance premium – capital standard satisfies:

$$P_M = \frac{1-p^*}{p^*}\left[R_F - d(1+k)\right]$$

- $p^* \equiv (R_F - d)/(R_L - d)$ is the **risk-neutral** probability of no default or “survival probability.”
- If the fair premium P_M is charged, the initial market value of the bank’s shareholders’ equity is $E_B = k$.

"Actuarially Fair" Deposit Insurance and Capital Standards

- For a given capital level, k, an actuarially fair premium, P_A, allows the government insurer to "break-even," on average:

$$P_A = \frac{1-p}{p}\left[R_F - d\left(1+k\right)\right]$$

- This insurance premium – capital standard is based on the physical survival probability, p.

- Under this standard, the value of bank shareholders' equity is

$$E_B = k + \frac{R_F - d\left(1+k\right)}{R_F}\left(1-\frac{p^*}{p}\right)$$

which exceeds k when $p > p^*$.

Business Cycles and Systematic Risk

- Assume there are two end-of-period macroeconomic states:

α = physical probability of an expansion

$1\text{-}\alpha$ = physical probability of a contraction

α^* = risk-neutral probability of an expansion

$1\text{-}\alpha^*$ = risk-neutral probability of a contraction

- Asset pricing theory predicts $\alpha^* < \alpha$, or $(1\text{-}\alpha^*) > (1\text{-}\alpha)$.

- Also, for a given portfolio of bank loans, let

p_e = portfolio's probability of no default given an expansion

p_c = portfolio's probability of no default given a contraction

- Portfolios have greater systematic risk as $p_e - p_c$ increases.

Systematic Risk and Moral Hazard

- Given this modeling, then the unconditional end-of-period physical and risk-neutral survival probabilities are

$$p = \alpha p_e + (1 - \alpha) p_c$$

$$p^* = \alpha^* p_e + (1 - \alpha^*) p_c$$

- Then, under an actuarially fair insurance – capital standard

$$\left. \frac{dE_B}{dp_c} \right|_{p \,=\, \text{constant}} = -\frac{R_F - d(1+k)}{R_F p} \left(1 - \frac{\alpha^*}{\alpha} \right) < 0$$

implying that the bank can increase E_B by selecting a loan portfolio with a relatively high (*low*) probability of default in the contraction (*expansion*) state.

Potential For Moral Hazard

- The model predicts that if deposit insurance premia and capital standards are based on loans' and securities' physical probabilities of default, banks have an incentive to choose loans and securities with the highest systematic risk.

- The intuition is that banks earn a systematic risk premium by investing such loans and securities, but are not penalized for this risk in the form of higher insurance premia or capital.

- Do current methods of setting deposit insurance premia or capital levels penalize systematic risk?

Deposit Insurance Premiums

- The U.S. FDIC and the proposed EU Deposit Guarantee Schemes set risk-based premiums to cover individual banks' physical expected losses to a deposit insurance fund (DIF).

- Moreover, the overall level of banks' premiums are adjusted to target the ratio of DIF reserves to deposits.

- But since fairly-priced deposit insurance contains a *systematic risk premium*, the level of DIF reserves to deposits should be expected to grow without bound under fair pricing.*

- Consequently, setting premia to target the ratio of DIF reserves to deposits is incompatible with fairly-priced deposit insurance.

*G. Pennacchi (2000) "The Effects of Setting Deposit Insurance Premiums to Target Insurance Fund Reserves." *Journal of Financial Services Research*.

Basel III Capital Standards

- Basel standards focus mostly on physical probabilities of default.
- The *Internal Ratings-Based Approach* requires that:
  - banks estimate *PD* (e.g., 1-p) and *LGD* (e.g., R_L-d) from internal models.
  - the correlation with macro-economy (systematic) risk is the same for broad classes of assets.
- The *Standardized Approach* sets capital based on credit ratings:
  - credit ratings of bonds and loans primarily reflect physical expected default losses.
  - credit spreads of bonds and loans contain systematic risk premia that reflect risk-neutral expected default losses.

Evidence of Systematic Default Risk Premia

- Iannotta and Pennacchi (2014) investigate whether corporate bond credit spreads contain systematic risk premia not accounted for by their credit ratings.*
- They estimate a bond's systematic risk or "debt beta" from its issuer's equity beta and volatility, and market leverage ratio.**
- As theory predicts, the following tables indicate that similarly-rated bonds have higher credit spreads (yields) when their issuers have relatively high systematic risk (debt betas).

*Working paper titled "Ratings-Based Regulation and Systematic Risk Incentives."
**D. Galai and R. Masulis (1976) "The Option Pricing Model and the Risk Factor of Stock." *Journal of Financial Economics*.

Systematic Risk Premia in Bond Yields

- Comparing similarly-rated bonds issued in the same year and currency, bonds whose issuers have higher debt beta (systematic risk) have significantly greater credit spreads.

Credit Spreads (in basis points) of Bonds Whose Issuers Have Above and Below Median Debt Betas

	AA			A			BBB		
	Above	Below	Difference	Above	Below	Difference	Above	Below	Difference
By Year	97.6	78.9	18.7*** (1,156)	122.1	107.6	14.5*** (1,587)	159.2	139.1	20.1** (1,049)
By Year - €	111.0	93.9	17.1** (304)	159.4	127.0	32.4*** (492)	228.5	175.8	52.7*** (346)
By Year - $	132.4	96.1	36.3*** (349)	179.5	147.2	32.3*** (430)	268.9	258.1	10.8 (164)
By Year –maturity above median	103.6	77.1	26.5*** (536)	128.9	120.8	8.1 (776)	177.3	155.9	21.4* (475)
By Year –maturity below median	94.6	78.7	15.9*** (620)	114.8	95.8	19.0** (811)	145.0	124.8	20.2 (574)

(Obs.). ***, **, * indicate 1%, 5%, 10% statistical significance of the t-test for the equality of bond credit spreads by issuers having above median versus below median debt betas.

Reaching for Yield Raises Systematic Risk

- A bank that each year selects similarly-rated bonds with above-median credit spreads significantly raises its systematic risk.

Debt Betas of Issuers Whose Bonds Have Above and Below Median Credit Spreads

	AA			A			BBB		
	Above	Below	Difference	Above	Below	Difference	Above	Below	Difference
By Year	0.091	0.067	0.024*** (1,156)	0.113	0.088	0.025*** (1,587)	0.120	0.087	0.033*** (1,049)
By Year - €	0.111	0.076	0.035** (304)	0.133	0.090	0.042*** (492)	0.161	0.089	0.072*** (346)
By Year - $	0.115	0.075	0.040*** (349)	0.148	0.098	0.050*** (430)	0.150	0.068	0.082*** (164)
By Year –maturity above median	0.084	0.062	0.022** (536)	0.100	0.082	0.019** (776)	0.114	0.070	0.044*** (475)
By Year –maturity below median	0.096	0.073	0.024** (620)	0.120	0.098	0.022** (811)	0.130	0.098	0.032*** (574)

(Obs.). ***, **, * indicate 1%, 5%, 10% statistical significance of the t-test for the equality of issuers' debt betas having bonds with above median versus below median credit spreads.

Implications for Capital Requirements

- Iannotta, Pennacchi, and Santos (2014) find that syndicated loan credit spreads also contain systematic risk premia not accounted for by their ratings.*

- Consider a bank that "reaches for yield" by selecting loans and bonds whose credit spreads are one standard deviation above the mean of equivalently-rated debt.

- If Basel risk weights are calibrated to the average risk of equally-rated debt, calculations in Iannotta and Pennacchi (2014) predict that the bank's fair capital should be 16% above the Basel required level.

*Work in progress.

Evidence of Regulatory-Induced Systematic Risk-Taking

- Research finds that highly-rated tranches of mortgage- and asset- backed securitizations had high systematic risk and credit spreads above those of equally-rated corporate bonds.*

- In 2001, U.S. regulators set credit rating-based risk weights for securitized tranches, creating incentives for banks to produce and invest in these highly-rated securities.

- U.S. insurance companies have been subject to ratings-based capital standards, and recent studies confirm that they invested in highly-rated but high-yielding, high systematic risk securities.**

*Coval, Jurek, and Stafford *AER* (2009), Collin-Dufresne, Goldstein, and Yang *JF* (2012).
**Becker and Ivashina *JF* (forthcoming), Chenenko, Hanson, and Sunderam (2014), Merrill, Nadauld, and Strahan (2014).

Importance of Stress Tests

- Stress tests have the potential to correct flaws in Basel capital standards.
- Because they are designed to measure losses during systematic downturns, stress tests may penalize banks that over-invest in systematically-risky loans and securities.
- However, the tests must detect differences in individual loans' and bonds' systematic risks:
  - more finely differentiate loans' and bonds' systematic risk exposure compared to the Basel IRB approach.
  - use credit spreads or debt beta, rather than credit ratings, to identify the systematic risks of loans and bonds.*

*A. Ashcraft and D. Morgan (2003) "Using Loan Rates to Measure and Regulate Bank Risk: Findings and an Immodest Proposal." *Journal of Financial Services Research*.

Estimating Risk-Neutral Probabilities

- Fortunately, risk-neutral probabilities are often easier and more accurately estimated than physical probabilities.

- Estimates of physical probabilities usually require a long historical time series, making it difficult to estimate:
  1. probabilities that may change over time.
  2. probabilities of rarely-observed "tail" events.

- Estimates of risk-neutral probabilities use market prices:
  1. current market prices reflect current probabilities.
  2. sufficient variety in market prices (e.g., options) permits more accurate estimation of tail probabilities.

Market Data for Estimating Risk-Neutral Failure Probabilities

- For a bank or firm with publicly-traded stock (equity), the market values, volatility, and beta of its equity, along with the book value of its liabilities, can be used to infer the market values and volatilities of its assets and liabilities.*

- In the context of a structural model of the bank or firm, its risk-neutral failure probabilities, fair deposit insurance premia, or fair capital standards can be estimated.**

- If a bank or firm has Credit Default Swap (CDS) contracts traded on its debt, CDS prices, and an estimate of *LGD*, can be used to infer risk-neutral default probabilities.***

*A. Marcus and I. Shaked (1984) "The Valuation of FDIC Deposit Insurance Using Option Pricing Estimates" *Journal of Money, Credit and Banking* first introduced this technique.
**See G. Pennacchi (2005) "Risk-Based Capital Standards, Deposit Insurance, and Procyclicality" *Journal of Financial Intermediation*.
*** See D. Duffie (1999) "Credit Swap Valuation" *Financial Analysts Journal*.

Risk-Neutral Probabilities for Privately-Held Banks and Firms

- A "market comparable" approach can estimate risk-neutral default probabilities, fair capital standards, or deposit insurance premia for banks without publically-traded equity.*

- The approach takes the following steps:
  1. Estimate the market values and volatilities of assets and liabilities for a sample of banks with publically-traded equity.
  2. Regress these market values and volatilities on the individual banks' financial statement and CAMELS data.
  3. Use the estimated regression to predict the market values and volatilities of assets and liabilities for private banks based on their financial statement and CAMELS data.
  4. Private banks' risk-neutral probabilities of default are simulated using a "nearest neighbors" approach that minimizes bias from estimation errors.

*M. Falkenheim and G. Pennacchi (2003) "The Cost of Deposit Insurance for Privately Held Banks: A Market Comparable Approach." *Journal of Financial Services Research*.

A Micro-Prudentially-Consistent Macro-Prudential Risk Measure

- Several aforementioned studies use risk-neutral default probabilities to calculate the fair market value of insuring individual banks' liabilities (deposit insurance).

- Huang, Zhou, and Zhu (2009, 2012) introduce a "Distress Insurance Premium" (*DIP*) that equals the value of insuring many banks' liabilities when total losses exceed a given threshold.

- Their approach embeds the method for valuing losses on individual banks' into the Vasicek (1991) portfolio loss framework.**

*"A Framework for Assessing the Systemic Risk of Major Financial Institutions," *Journal of Banking and Finance* (2009) and "Systemic Risk Contributions" J*ournal of Financial Services Research* (2012).

**O. Vasicek (1991) "The Limiting Loan Loss Probability Distribution." KMV working paper.

Distress Insurance Premium

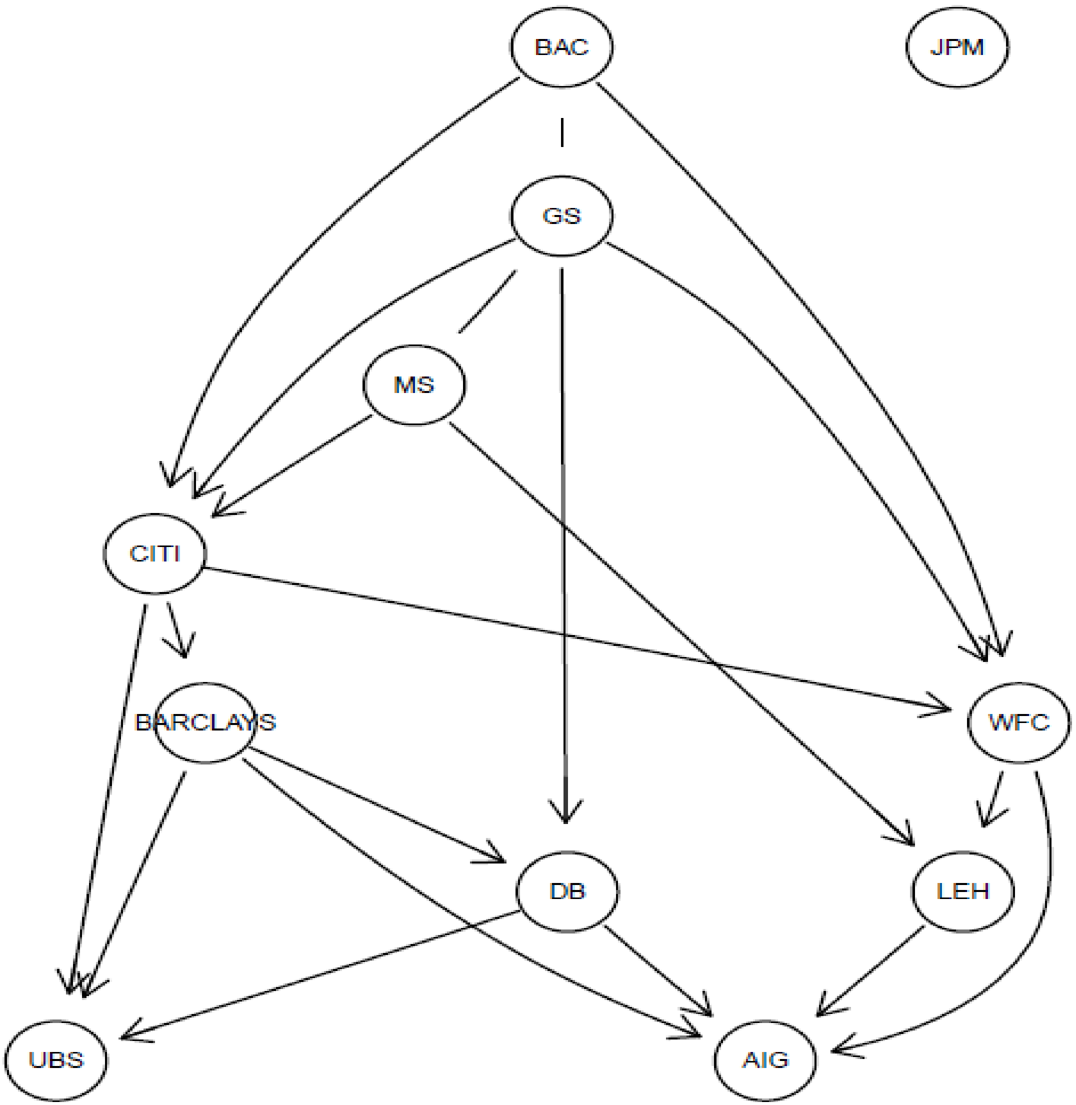
- If L_i is the default loss on Bank *i*'s debt, and there are *n* banks in the system, total losses equal $L = \sum_{i=1}^{n} L_i$.
- Then the *DIP* is defined as $E^Q[L \mid L \geq L_{min}]$ where L_{min} is the threshold where total bank losses become systemic.
- Bank *i*'s contribution to systemic risk is defined as
$$\partial DIP / \partial L_i \equiv E^Q\left[L_i \mid L \geq L_{\min}\right]$$
- *DIP* and $\partial DIP/\partial L_i$ are calculated by Monte Carlo simulation for specified risk-neutral bank default probabilities and correlations.
- Default probabilities and correlations are inferred from CDS written on each bank's debt and banks' equity returns.
- This is a flexible approach that can be generalized to multiple periods with changing default probabilities and correlations.

Market Prices Reflect Both Common Exposures and Contagion

- Rational investors should recognize that systematic risks derive from both “common exposures” and “contagion.”
- In principle, CDS, debt, and equity prices should reflect both sources of systematic risk.
- Kitwiwattanachai (2014) uses a time series – cross section of financial institution CDS spreads to estimate a financial network structure based on a probabilistic graphical model.*
- The probabilistic graph model identifies those financial institutions that are “parents” (transmit shocks) versus those that are “children” (receive shocks).

*Chanatip Kitwiwattanachai (2014) “Learning Network Structure of Financial Institutions from CDS Data,” University of Connecticut working paper.

Network Structure Estimated from CDS Spreads



Source: C. Kitwiwattanachai (2014)

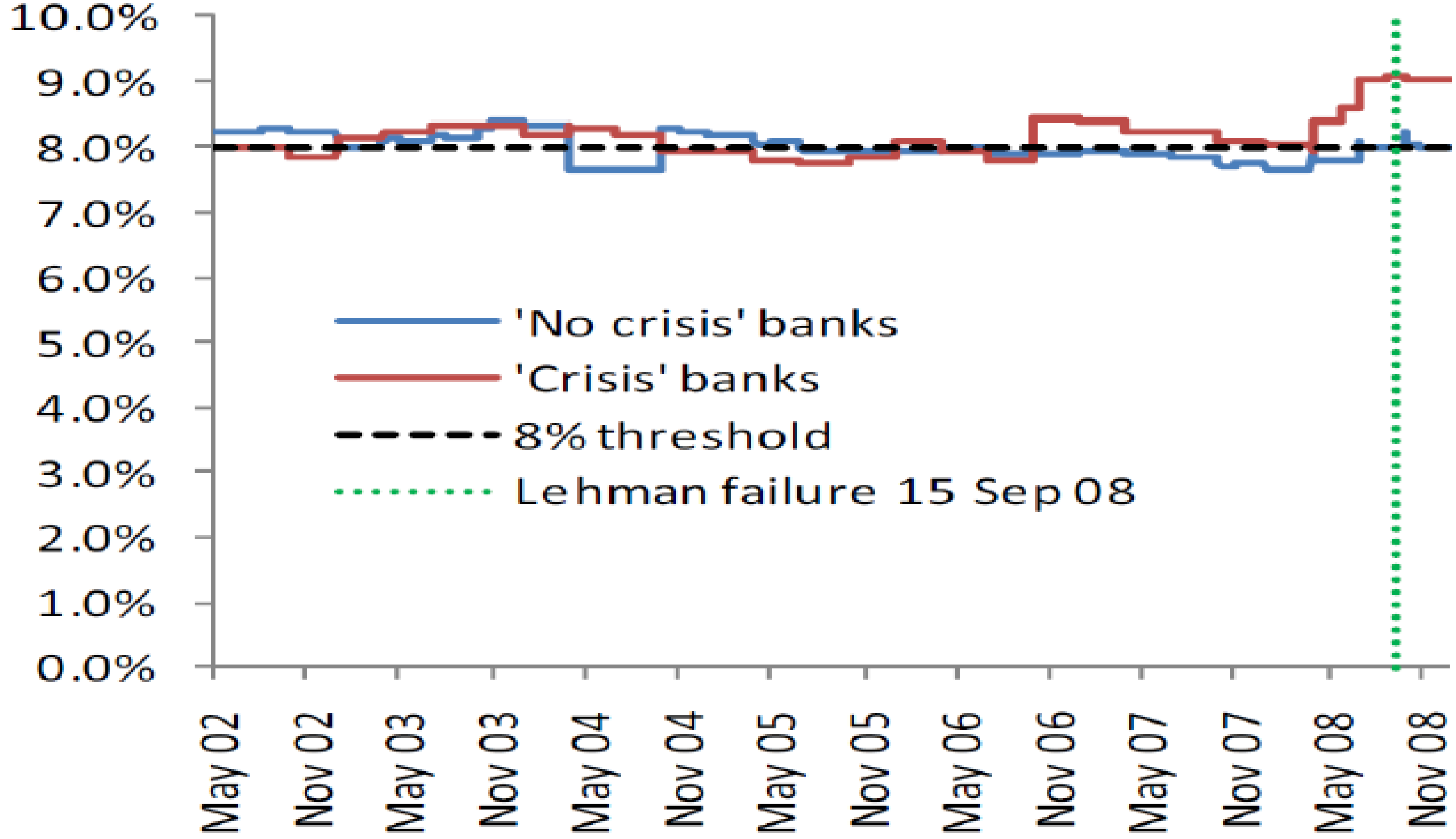
Caveats with Using Market Prices

- Goodhart's Law or the Lucas Critique might apply to the use of market prices by bank regulators.
- Bond et al. (2010) and Bond and Goldstein (2014) warn that if bank regulators learn and take corrective actions based on market prices, the information content of prices can decline if speculators' incentives for trading decrease.*
- However, there is also a downside when regulators base decisions on accounting data.
- Evidence suggests that banks manipulate their regulatory capital ratios as they near financial distress.**

*Bond, Goldstein, and Prescott (2010) *RFS* and Bond and Goldstein *JF* (forthcoming).
**O. Merrouche and M. Mariathasan (2014) "The Manipulation of Basel Risk Weights: Evidence from 2007-2010," *Journal of Financial Intermediation*.

Tier 1 Regulatory Capital During the Crisis

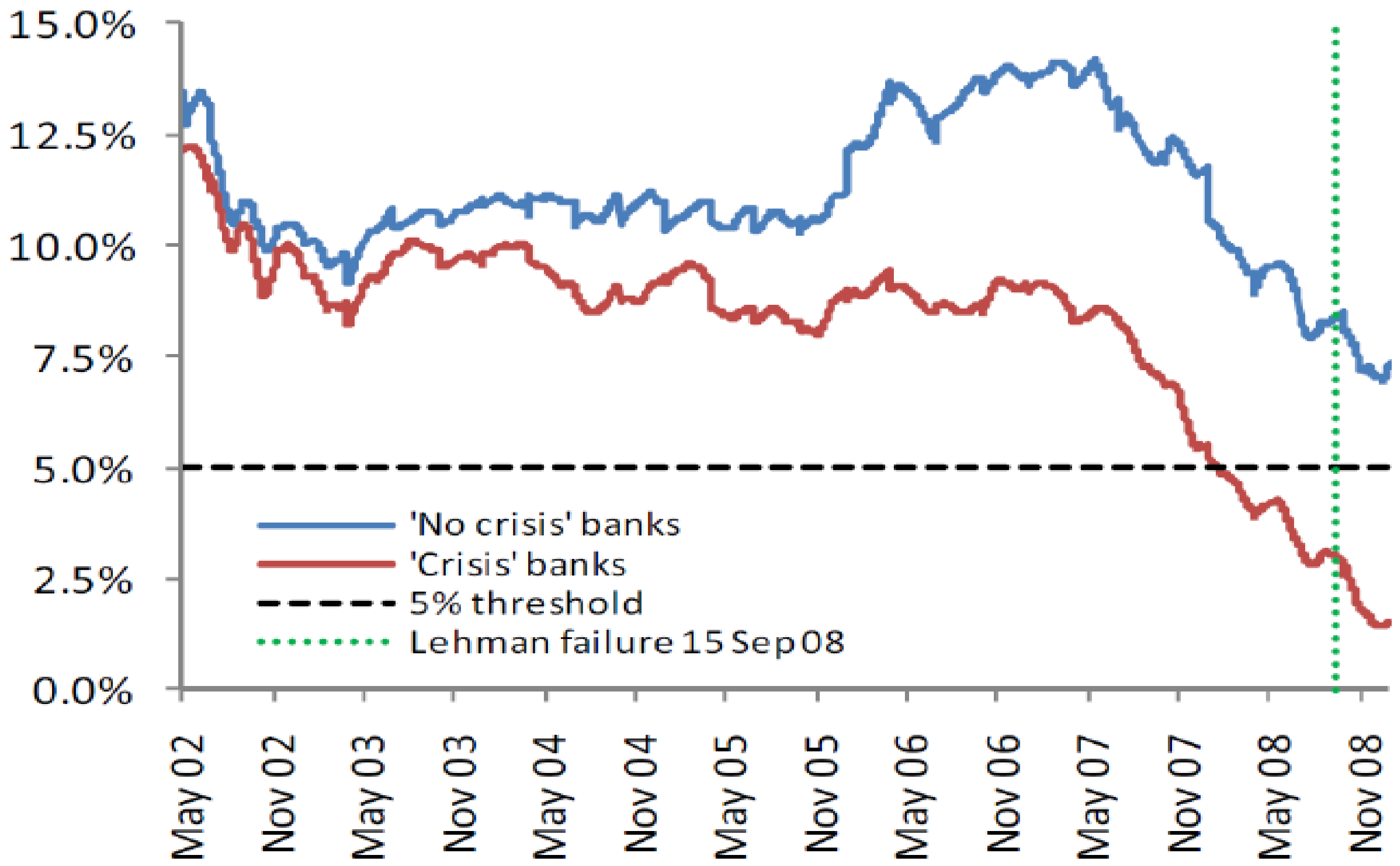
- "Crisis banks" (*No crisis banks*) received (*did not receive*) government support.



Source: A. Haldane (2011) "Capital Discipline," Bank of England working paper.

Market Value of Capital During the Crisis

- Banks’ market capitalization to book-value of debt.



Source: A. Haldane (2011) “Capital Discipline,” Bank of England working paper.

Conclusions

- It is important that bank regulatory standards penalize systematic risk taking.
- To prevent regulatory arbitrage, capital requirements and deposit insurance premiums should be based on risk-neutral probabilities of losses.
- Timely estimation of risk-neutral probabilities are possible from market data, such as CDS spreads and bank equity prices.
- Systemic risk indicators can be consistent with micro-prudential regulatory standards.