

Banking Stability Measures and Macroeconomic Stress Testing



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Objective

Interested not only on assessing the risk of large losses (and possibly default) of *one specific* financial institution but on the *impact* that such an event would have on the *system*.

Outline

I. Banking Stability Measures

Empirical Analysis

II. Financial Stability Framework

III. Macroeconomic Stress Testing

Empirical Analysis

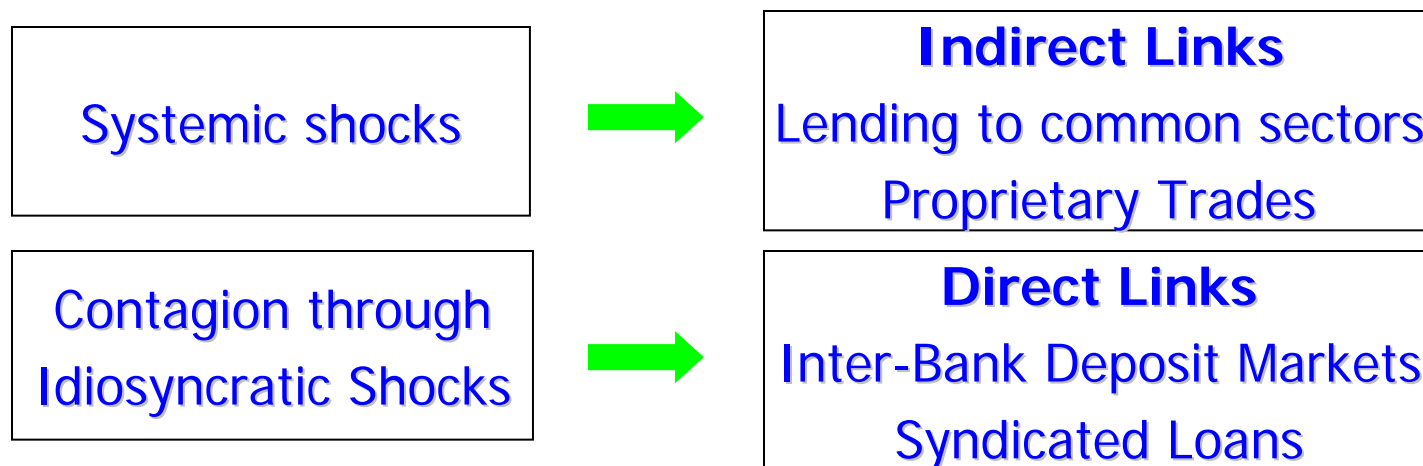
Methodology: Three Relevant Principles

- 1. Readily implementable in terms of data needs.**
- 2. Reliable in the sense of being robust under data-restricted environments.**
- 3. Economically interpretable, so it can be used as an input to policy discussions.**

III. Banking Stability Measures

Banking Stability Measures: Introduction

Fortunes of banks move in tandem



Reflected in **concurrent** movements in banks' *individual* measures of distress.

Thus, proper estimation of **distress dependence** is of key importance

(Goodhart, Sunirand, Tsomocos, 2004)

Banking Stability Measures: Key Contributions

- Can be constructed from **alternative market-based** measures of distress of individual banks, which are available publicly.
- Account for the ***Distress Dependence (DD)*** amongst banks in the system.
- Embed ***changes*** in ***DD*** at ***different points in the economic cycle***; hence, useful to quantify empirically observed increases in dependencies at periods of distress.
- Flexible to **incorporate other FI's**.

Banking Stability Measures: Key Contributions

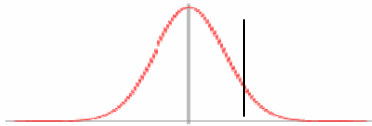
Set of tools to analyze (define) banking stability from **different**, yet, **complementary** perspectives:

1. **Common** distress in the banks in a system.
2. Distress **between** specific banks.
3. Distress **in the system** caused by a specific bank; i.e., “cascade effects”.

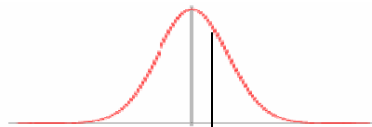
Banking Stability Measures: Modeling Steps

Step 1:

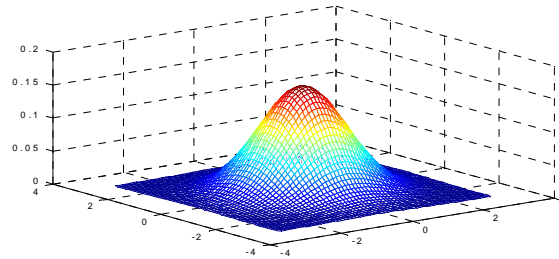
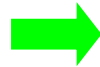
View the banking system as a portfolio of banks.



PoD of Bank X



PoD of Bank Y



Step 4:

Estimate BSMD

Step 2:

Estimate individual Banks' PoDs

Step 3:

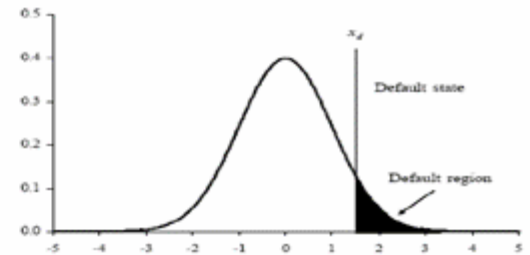
Recover the BSMD
CIMDO-density

CIMDO-density

The CIMDO density is recovered by minimizing the functional

$$\begin{aligned}
 L[p, q] = & \int \int p(x, y) \ln p(x, y) dx dy - \int \int p(x, y) \ln q(x, y) dx dy \\
 & + \lambda_1 \left[\int \int p(x, y) \chi_{[x_a^a, \infty)} dx dy - P_o D_t^x \right] \\
 & + \lambda_2 \left[\int \int p(x, y) \chi_{[x_a^y, \infty)} dy dx - P_o D_t^y \right] \\
 & + \mu \left[\int \int p(x, y) dx dy - 1 \right],
 \end{aligned}$$

Empirical
Information



CIMDO-copula

$$\widehat{p}(x, y) = q(x, y) \exp \left\{ - \left[1 + \widehat{\mu} + \left(\widehat{\lambda}_1 \chi_{[x_2^*, \infty)} \right) + \left(\widehat{\lambda}_2 \chi_{[x_2^*, \infty)} \right) \right] \right\}$$

$$c[u, v] = \frac{g[F^{(-1)}(u), H^{(-1)}(v)]}{f[F^{(-1)}(u)]h[H^{(-1)}(v)]}$$

$$c_c(u, v) = \frac{q[F_c^{-1}(u), H_c^{-1}(v)] \exp \left\{ - \left[1 + \widehat{\mu} \right] \right\}}{\int_{-\infty}^{+\infty} q[F_c^{-1}(u), y] \exp \left\{ - \widehat{\lambda}_2 \chi_{x_2^*}(y) \right\} dy \int_{-\infty}^{+\infty} q[x, H_c^{-1}(v)] \exp \left\{ - \widehat{\lambda}_1 \chi_{x_2^*}(x) \right\} dx}$$

CIMDO-Copula (Segoviano, 2008 forthcoming)

- Maintains the benefits of copula modeling (vs correlation).
- Readily implementable with available data.
- Avoids copula choice problem.
- Allows for changing dependence as empirical PoDs change, consistent with economic cycle.
- Outperforms commonly used parametric copula functions under the PIT criterion.

II. Banking Stability Measures

Banking Stability Measures: Common Distress

1. Joint Probability of Distress (JPOD): $P(X \cap Y \cap R)$

$$\int_{x_d^*}^{\infty} \int_{y_d^*}^{\infty} \int_{r_d^*}^{\infty} p(x, y, r) dx dy dr = JPOD$$

2. Banking Stability Index (BSI)

Expected number of banks in distress given that at least one became distressed

Measure of conditional expectation of distress probability (Huang 1992)

$$BSI = \frac{P(X \geq x_d^*) + P(Y \geq y_d^*)}{1 - P(X < x_d^*, Y < y_d^*)}$$

Stability Measures: Distress between banks

1. Distress Dependence Matrix (DiDe)

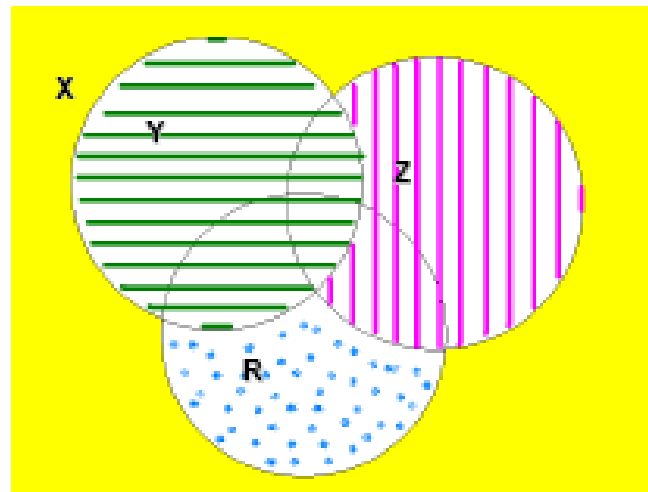
	X	Y	R
X	1	$P(X/Y)$	$P(X/R)$
Y	$P(Y/X)$	1	$P(Y/R)$
R	$P(R/X)$	$P(R/Y)$	1

Stability Measures:

Distress in the system caused by a bank

1. Probability that at least one becomes distressed conditional on a specific bank becoming distressed (PAO)

Measure of “cascade” effects in the system.



Source: Goodhart and Segoviano (2008)

III. Banking Stability Measures: Empirical Analysis

Modeling Individual Banks' PoDs

Structural Approach

- Economically intuitive
- Explicit definition of default
- Relies on stock prices and balance sheet liability information
- Choice and calibration of distribution of stock (asset) prices challenging
- Very sensitive to volatility values
- Difficult to separate volatility of equity market from volatility of a particular firm
- Off balance sheet items?

CDS Spreads

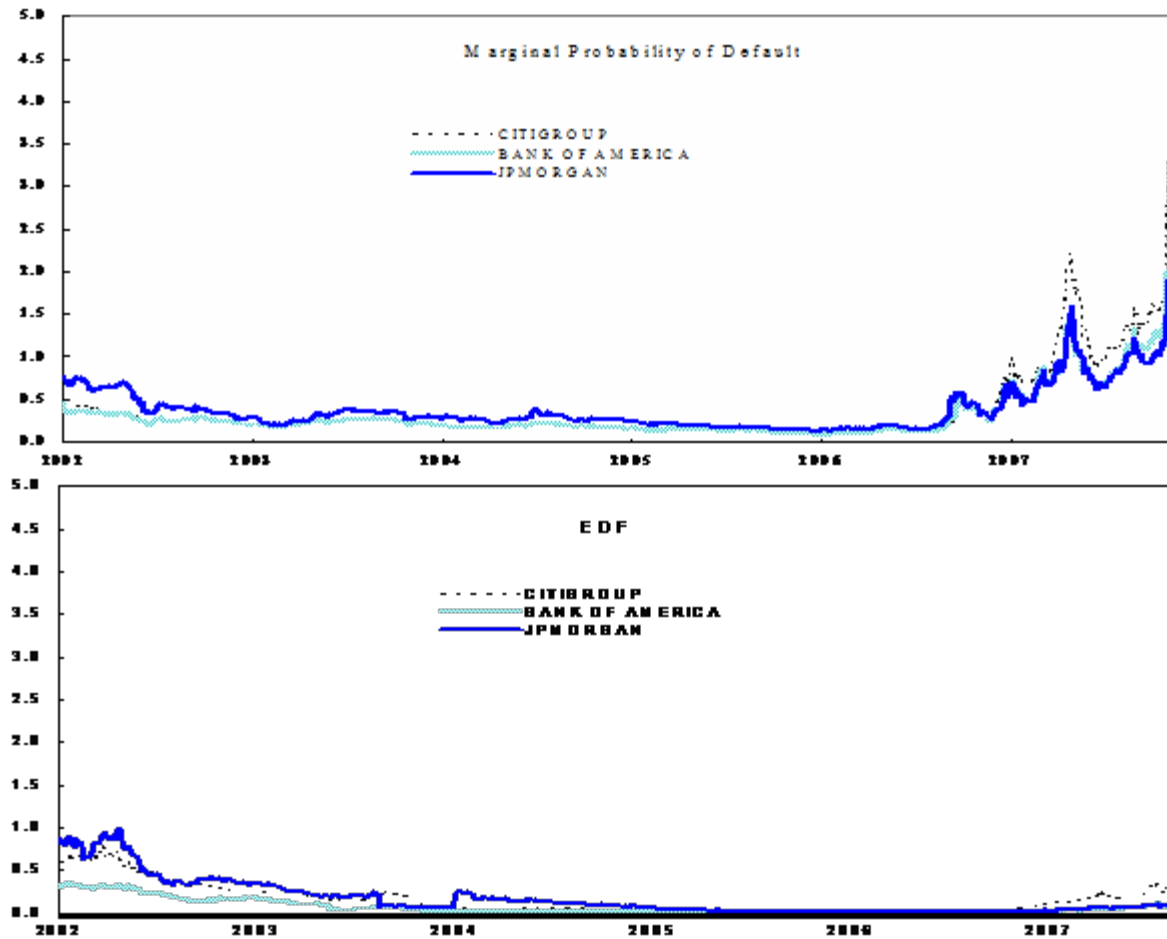
- Not subject to modeling distribution of asset prices, volatilities of stock prices and balance sheet liability information.
- Available only for few large banks
- Subject to market volatility and liquidity

OOM Prices

- Not subject to distribution calibrations, modeling of volatilities, recovery rates, delivery options
- Plain vanilla options might be available for smaller banks
- Availability of OOM option prices at different strike prices
- Model calibrations

Modeling Individual Banks' PoDs

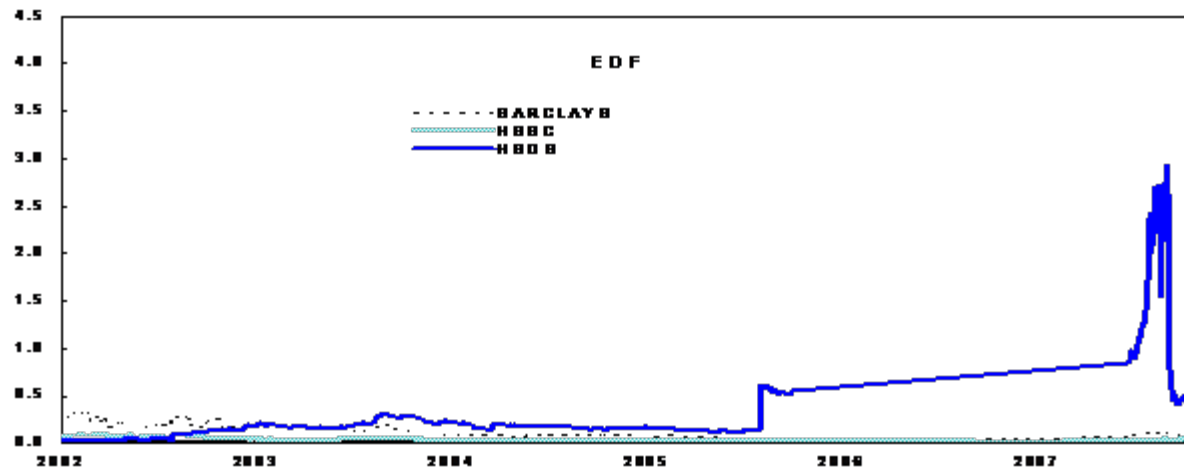
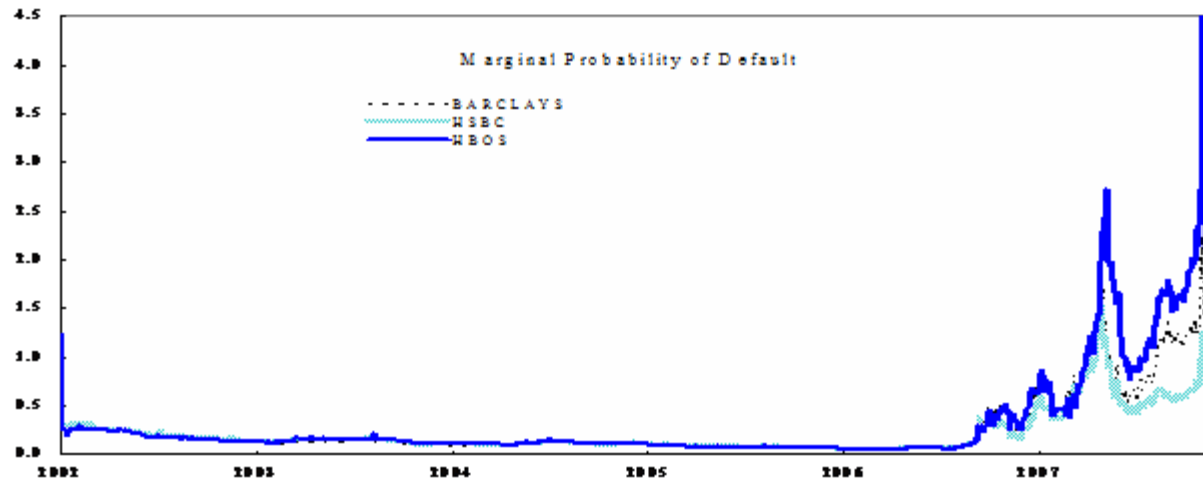
Major US BHCs: Marginal Probability of Default and KMV's 1-year Expected Default Frequency (EDF), November 2002-October 2008 (In percent)



Source: Moody's KMV and author's calculations.

Modeling Individual Banks' PoDs

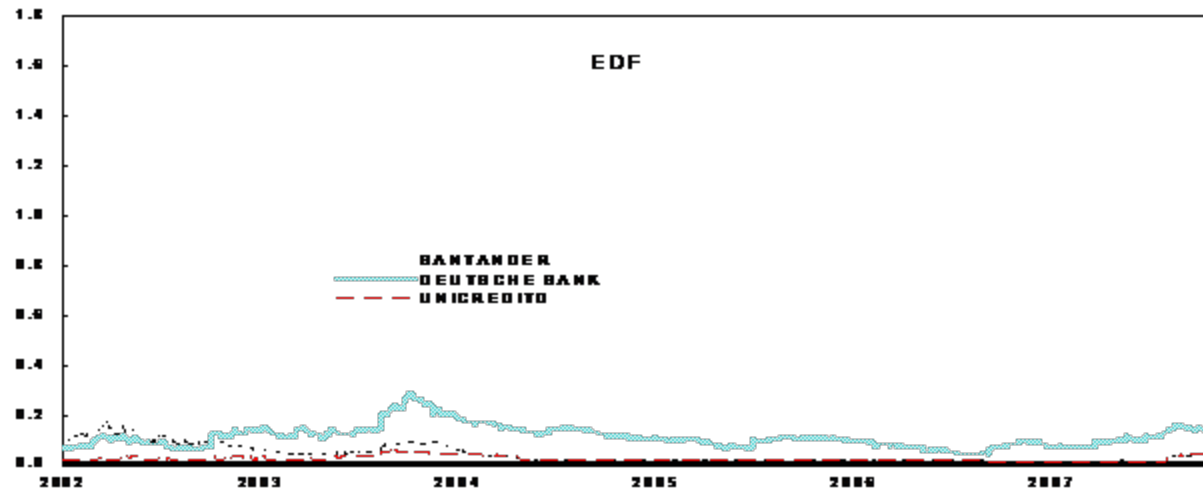
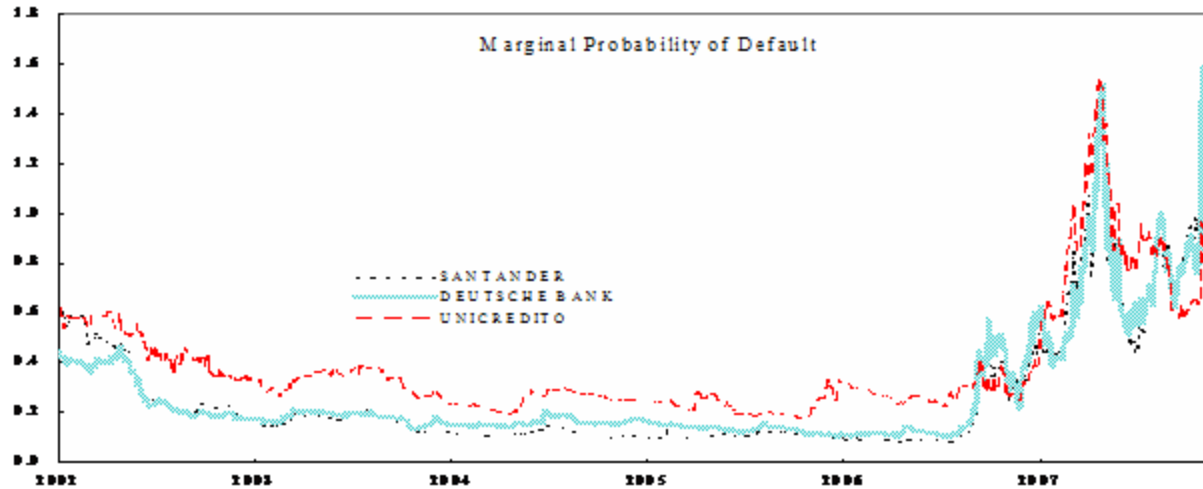
Major UK Banks: Marginal Probability of Default and M KMV's 1-year Expected Default Frequency (EDF), November 2002–October 2008
(In percent)



Source: Moody's KMV and authors' calculations.

Modeling Individual Banks' PoDs

European Banks: Marginal Probability of Default and KMV's 1-year Expected Default Frequency (EDF), November 2002–October 2008
(In percent)



Source: Moody's KMV and authors' calculations.

Modeling Individual Banks' PoDs

Chose CDS-PoDs; however,

CDS might exaggerate a firm's "fundamental risk" when:

- Lack of liquidity in the particular CDS market.
- General risk aversion in the financial system (also affecting the other two approaches).

These factors can become self-fulfilling if they affect market's perception and willingness to fund a firm

- CDS might overshoot at times but do not generally stay wrong for long.
- CDS anticipate rating changes.
- Magnitude might be unrealistic but direction a good distress signal.

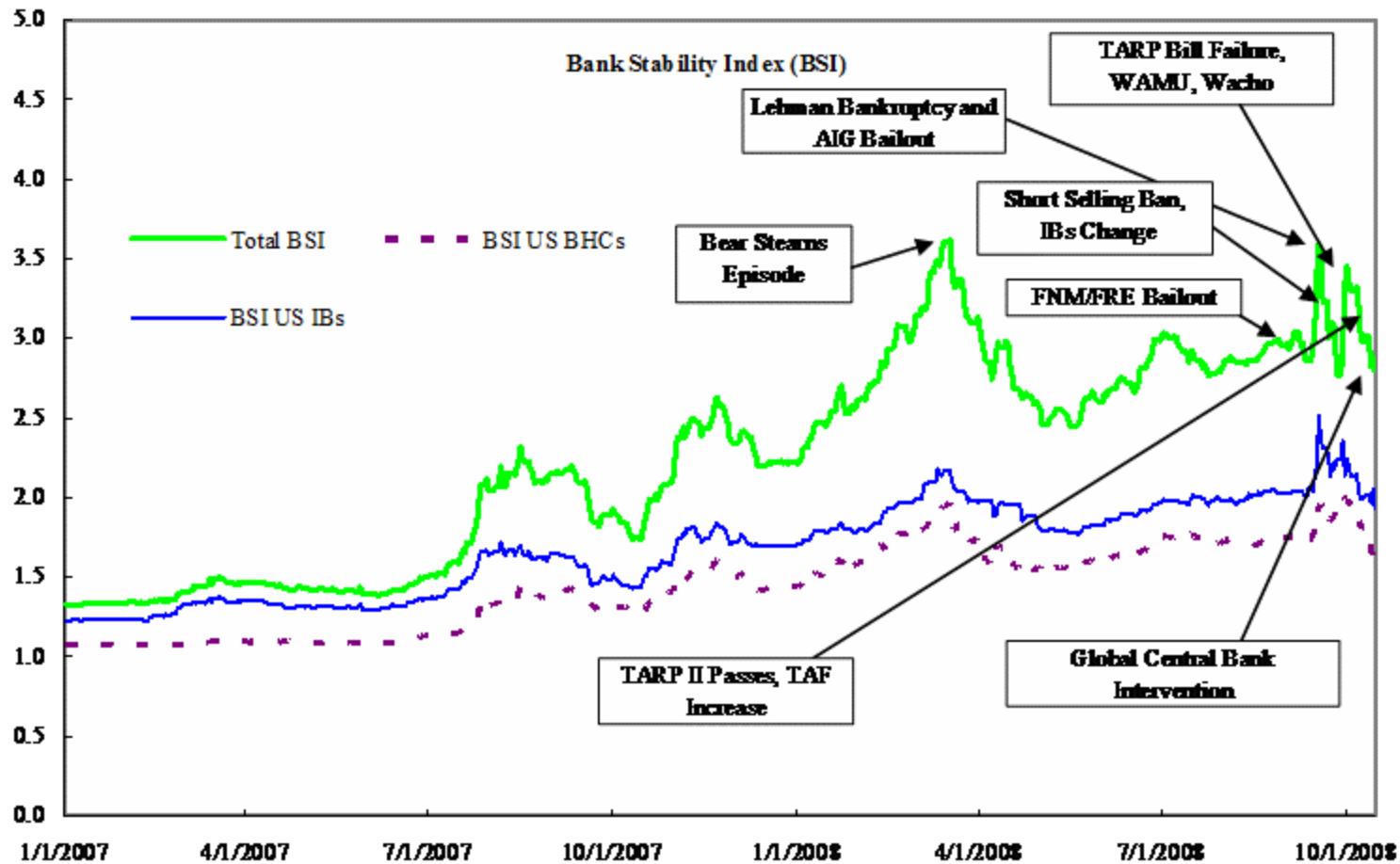
No measure is perfect, so we continue research in this field

PoDs are exogenous; thus possibility to implement model with any chosen measure

**Application 1:
Examination of Relative Changes of Stability
over time**

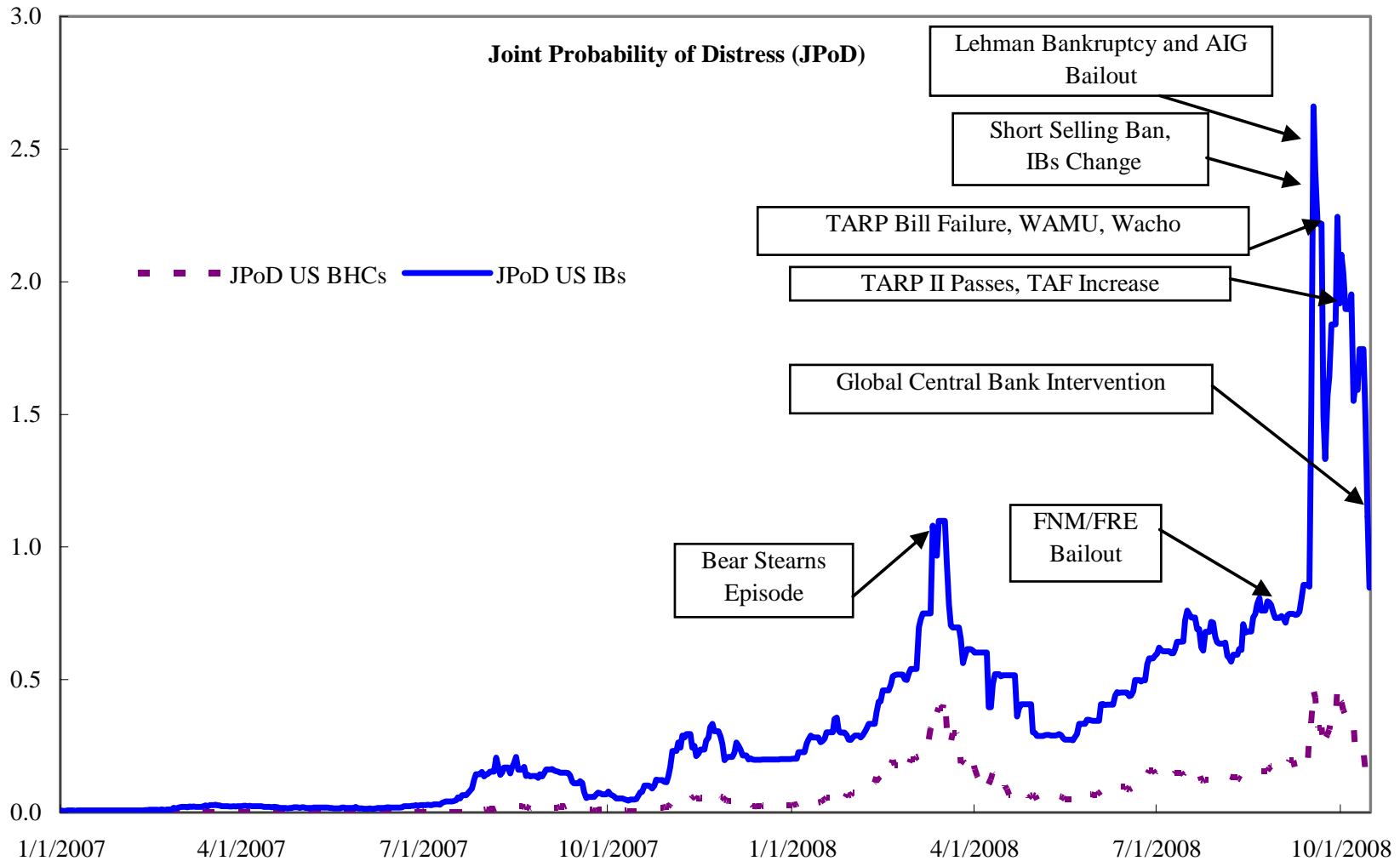
Perspective 1: Common Distress

Banking Stability Index: January 2007- October 2008



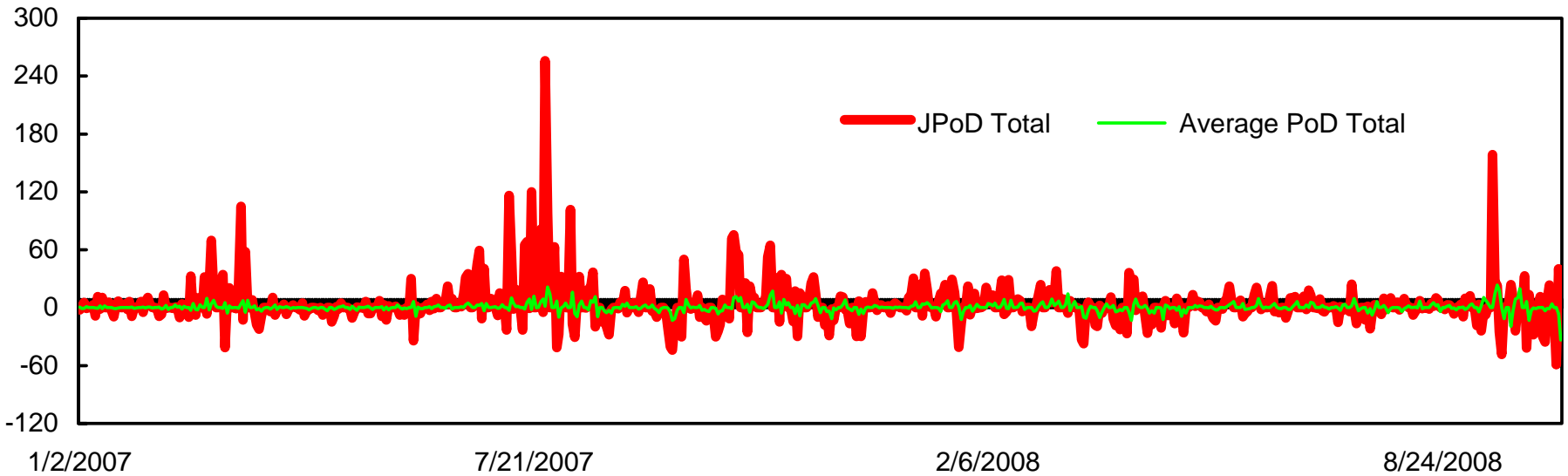
Perspective 1: Common Distress

Joint Probability of Distress: January 2007- October 2008



Perspective 1: Common Distress

Distress Dependence embedded in JPoD



Perspective 2: Distress Between Banks

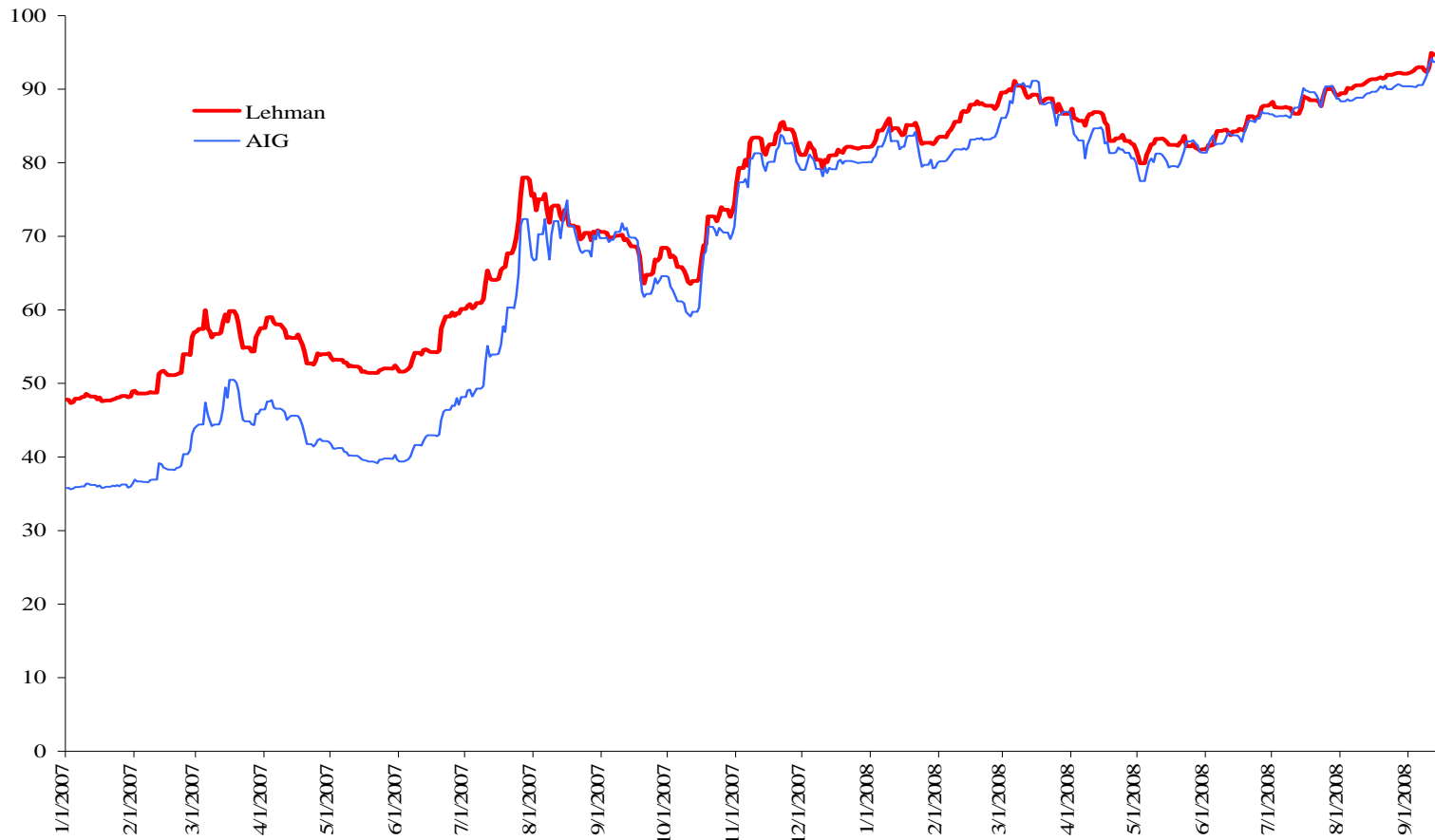
Distress Dependence Matrix: July 1, 2007- September 12, 2008

July 1, 2007	Citi	BAC	JPM	Wacho	WAMU	GS	LEH	MER	MS	AIG	Row average
Citigroup	1.00	0.14	0.11	0.11	0.08	0.09	0.08	0.09	0.09	0.08	0.19
Bank of America	0.12	1.00	0.27	0.27	0.11	0.11	0.10	0.12	0.12	0.15	0.24
JPMorgan	0.15	0.42	1.00	0.31	0.13	0.19	0.16	0.19	0.18	0.17	0.29
Wachovia	0.12	0.33	0.24	1.00	0.11	0.12	0.10	0.12	0.12	0.14	0.24
Washington Mutual	0.16	0.28	0.21	0.23	1.00	0.12	0.12	0.16	0.13	0.15	0.26
Goldman Sachs	0.17	0.25	0.28	0.21	0.11	1.00	0.31	0.28	0.31	0.17	0.31
Lehman	0.22	0.32	0.32	0.26	0.15	0.43	1.00	0.35	0.33	0.20	0.36
Merrill Lynch	0.19	0.32	0.33	0.25	0.17	0.33	0.31	1.00	0.31	0.20	0.34
Morgan Stanley	0.19	0.31	0.28	0.24	0.14	0.35	0.28	0.30	1.00	0.16	0.33
AIG	0.07	0.14	0.10	0.10	0.05	0.07	0.06	0.07	0.06	1.00	0.17
Column average	0.24	0.35	0.31	0.30	0.21	0.28	0.25	0.27	0.26	0.24	0.27

September 12, 2008	Citi	BAC	JPM	Wacho	WAMU	GS	LEH	MER	MS	AIG	Row average
Citigroup	1.00	0.20	0.19	0.14	0.07	0.17	0.11	0.14	0.16	0.11	0.23
Bank of America	0.14	1.00	0.31	0.18	0.05	0.16	0.10	0.13	0.15	0.11	0.23
JPMorgan	0.13	0.29	1.00	0.16	0.05	0.19	0.11	0.14	0.16	0.09	0.23
Wachovia	0.34	0.60	0.55	1.00	0.17	0.36	0.27	0.31	0.34	0.29	0.42
Washington Mutual	0.93	0.97	0.95	0.94	1.00	0.91	0.88	0.92	0.91	0.89	0.93
Goldman Sachs	0.15	0.19	0.24	0.13	0.06	1.00	0.18	0.20	0.27	0.11	0.25
Lehman	0.47	0.53	0.58	0.43	0.25	0.75	1.00	0.59	0.62	0.37	0.56
Merrill Lynch	0.32	0.41	0.47	0.30	0.16	0.53	0.37	1.00	0.48	0.26	0.43
Morgan Stanley	0.21	0.28	0.29	0.19	0.09	0.40	0.22	0.27	1.00	0.14	0.31
AIG	0.50	0.66	0.59	0.53	0.29	0.54	0.43	0.49	0.47	1.00	0.55
Column average	0.42	0.51	0.52	0.40	0.22	0.50	0.37	0.42	0.46	0.34	0.41

Perspective 3: Distress in the System Caused by a Bank

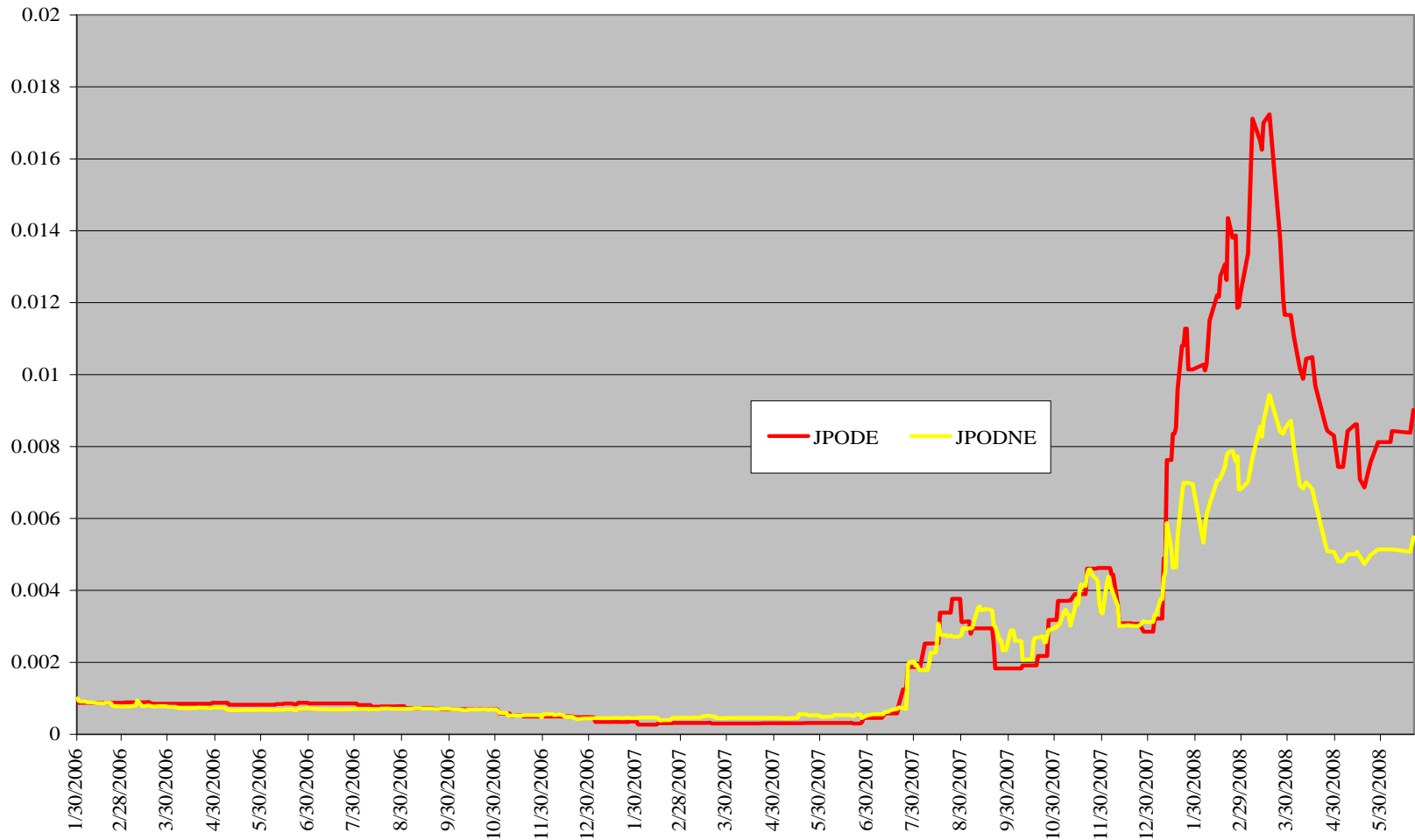
Probability that at least one bank becomes distressed given that Lehman/AIG become distressed (September 12)



**Application 2:
Examination of Cross-Region Effects
between Banking Groups**

Perspective 1: Common Distress

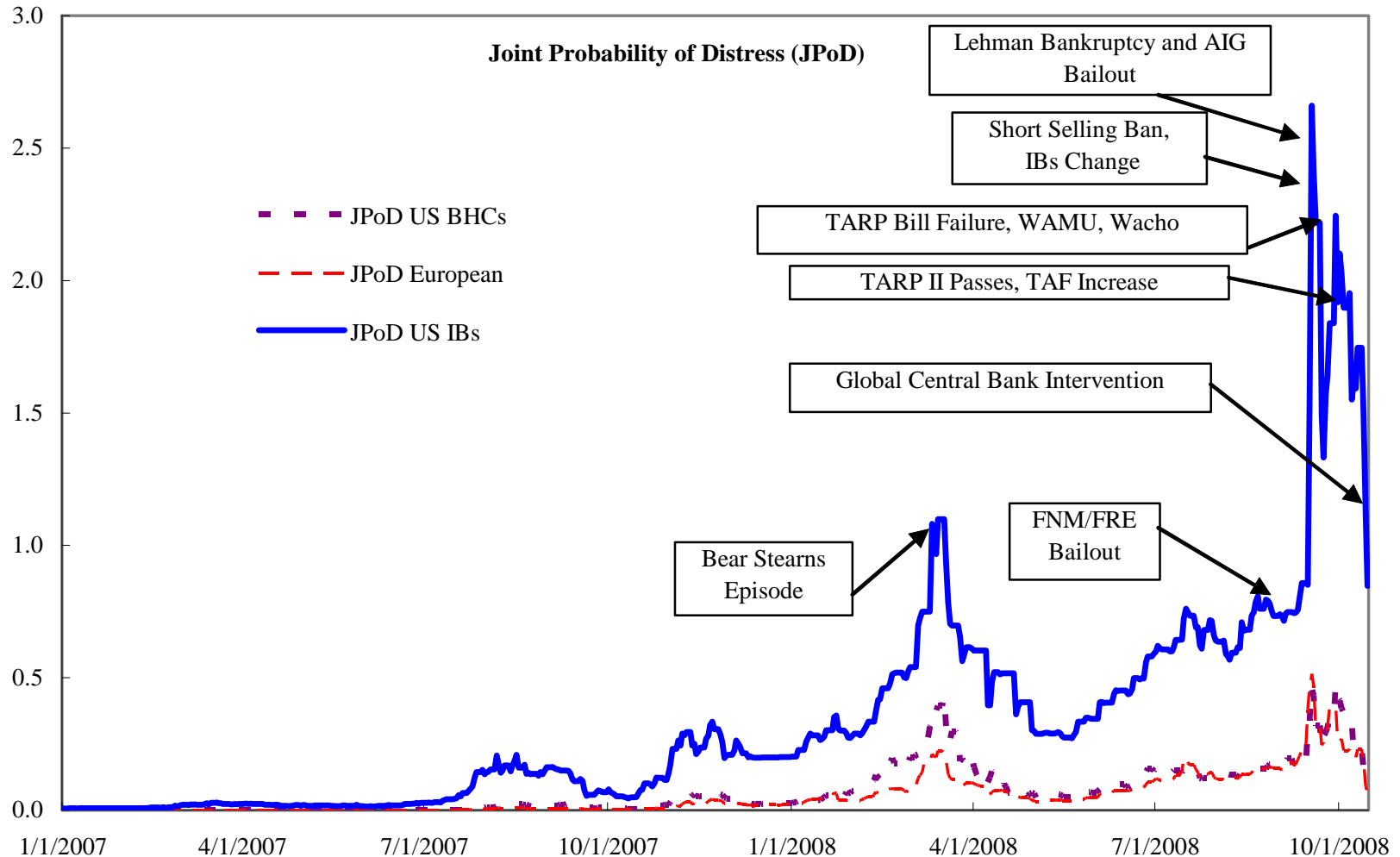
JPoD Scandinavian banks with and without exposure to Baltics



Source: Maeckler and Segoviano (2008)

Perspective 1: Common Distress

Joint Probability of Distress: January 2007- October 2008



Perspective 2: Distress Between Banks

Distress Dependence Matrices, July 2007 and September 2008 1/

July 1, 2007	Citi	BAC	JPM	Wacho	WAMU	GS	LEH	MER	MS	AIG	Row average		BARC	HSBC	UBS	CSFB	DB	Row average
Citigroup	1.00	0.14	0.11	0.11	0.08	0.09	0.08	0.09	0.09	0.08	0.19	Citigroup	0.07	0.07	0.08	0.06	0.07	0.07
Bank of America	0.12	1.00	0.27	0.27	0.11	0.11	0.10	0.12	0.12	0.15	0.24	Bank of America	0.08	0.07	0.09	0.06	0.10	0.08
JPMorgan	0.15	0.42	1.00	0.31	0.13	0.19	0.16	0.19	0.18	0.17	0.29	JPMorgan	0.10	0.08	0.12	0.09	0.14	0.10
Wachovia	0.12	0.33	0.24	1.00	0.11	0.12	0.10	0.12	0.12	0.14	0.24	Wachovia	0.07	0.05	0.07	0.05	0.08	0.07
Washington Mutual	0.16	0.28	0.21	0.23	1.00	0.12	0.12	0.16	0.13	0.15	0.26	Washington Mutual	0.09	0.08	0.09	0.06	0.09	0.08
Goldman Sachs	0.17	0.25	0.28	0.21	0.11	1.00	0.31	0.28	0.31	0.17	0.31	Goldman Sachs	0.13	0.11	0.15	0.12	0.18	0.14
Lehman	0.22	0.32	0.32	0.26	0.15	0.43	1.00	0.35	0.33	0.20	0.36	Lehman	0.14	0.12	0.15	0.14	0.22	0.15
Merrill Lynch	0.19	0.32	0.33	0.25	0.17	0.33	0.31	1.00	0.31	0.20	0.34	Merrill Lynch	0.15	0.15	0.19	0.15	0.21	0.17
Morgan Stanley	0.19	0.31	0.28	0.24	0.14	0.35	0.28	0.30	1.00	0.16	0.33	Morgan Stanley	0.14	0.12	0.14	0.12	0.18	0.14
AIG	0.07	0.14	0.10	0.10	0.05	0.07	0.06	0.07	0.06	1.00	0.17	AIG	0.05	0.06	0.07	0.04	0.06	0.06
Column average	0.24	0.35	0.31	0.30	0.21	0.28	0.25	0.27	0.26	0.24	0.27	Column average	0.10	0.09	0.11	0.09	0.13	0.11
	Citi	BAC	JPM	Wacho	WAMU	GS	LEH	MER	MS	AIG	Row average		BARC	HSBC	UBS	CSFB	DB	Row average
Barclay's	0.04	0.05	0.04	0.04	0.02	0.04	0.03	0.04	0.04	0.04	0.04	Barclay's	1.00	0.18	0.18	0.12	0.12	0.32
HSBC	0.04	0.04	0.03	0.02	0.02	0.03	0.02	0.03	0.03	0.04	0.03	HSBC	0.16	1.00	0.13	0.09	0.11	0.30
UBS	0.04	0.05	0.04	0.03	0.02	0.04	0.03	0.04	0.03	0.04	0.04	UBS	0.17	0.13	1.00	0.21	0.15	0.33
CSFB	0.05	0.06	0.05	0.04	0.03	0.05	0.05	0.06	0.05	0.05	0.05	CSFB	0.19	0.15	0.36	1.00	0.21	0.38
Deutsche Bank	0.05	0.09	0.08	0.06	0.03	0.07	0.06	0.07	0.06	0.06	0.06	Deutsche Bank	0.17	0.16	0.22	0.19	1.00	0.35
Column average	0.05	0.06	0.05	0.04	0.02	0.05	0.04	0.05	0.04	0.05	0.04	Column average	0.34	0.32	0.38	0.32	0.32	0.34
	Citi	BAC	JPM	Wacho	WAMU	GS	LEH	MER	MS	AIG	Row average		BARC	HSBC	UBS	CSFB	DB	Row average
September 12, 2008																		
Citigroup	1.00	0.20	0.19	0.14	0.07	0.17	0.13	0.14	0.16	0.11	0.23	Citigroup	0.15	0.17	0.17	0.15	0.16	0.16
Bank of America	0.14	1.00	0.31	0.18	0.05	0.16	0.10	0.13	0.15	0.11	0.23	Bank of America	0.12	0.13	0.13	0.11	0.15	0.13
JPMorgan	0.13	0.29	1.00	0.16	0.05	0.19	0.11	0.14	0.16	0.09	0.23	JPMorgan	0.11	0.10	0.12	0.11	0.15	0.12
Wachovia	0.34	0.60	0.55	1.00	0.17	0.36	0.27	0.31	0.34	0.29	0.42	Wachovia	0.27	0.23	0.27	0.25	0.31	0.27
Washington Mutual	0.93	0.97	0.95	0.94	1.00	0.91	0.88	0.92	0.91	0.89	0.93	Washington Mutual	0.87	0.86	0.86	0.83	0.86	0.86
Goldman Sachs	0.15	0.19	0.24	0.13	0.06	1.00	0.18	0.20	0.27	0.11	0.25	Goldman Sachs	0.14	0.13	0.15	0.15	0.19	0.15
Lehman	0.47	0.53	0.58	0.43	0.25	0.75	1.00	0.59	0.62	0.37	0.56	Lehman	0.39	0.37	0.40	0.42	0.52	0.42
Merrill Lynch	0.32	0.41	0.47	0.30	0.16	0.53	0.37	1.00	0.48	0.26	0.43	Merrill Lynch	0.31	0.33	0.35	0.35	0.39	0.35
Morgan Stanley	0.21	0.28	0.29	0.19	0.09	0.40	0.22	0.27	1.00	0.14	0.31	Morgan Stanley	0.18	0.18	0.18	0.18	0.23	0.19
AIG	0.50	0.66	0.59	0.53	0.29	0.54	0.43	0.49	0.47	1.00	0.55	AIG	0.49	0.53	0.53	0.49	0.53	0.52
Column average	0.42	0.51	0.52	0.40	0.22	0.50	0.37	0.42	0.46	0.34	0.41	Column average	0.30	0.30	0.32	0.31	0.35	0.32
	Citi	BAC	JPM	Wacho	WAMU	GS	LEH	MER	MS	AIG	Row average		BARC	HSBC	UBS	CSFB	DB	Row average
Barclay's	0.10	0.11	0.10	0.08	0.04	0.10	0.07	0.09	0.09	0.07	0.08	Barclay's	1.00	0.36	0.31	0.30	0.28	0.45
HSBC	0.06	0.06	0.05	0.03	0.02	0.05	0.04	0.05	0.05	0.04	0.05	HSBC	0.20	1.00	0.16	0.16	0.17	0.24
UBS	0.11	0.11	0.11	0.07	0.04	0.11	0.07	0.10	0.09	0.08	0.09	UBS	0.32	0.30	1.00	0.47	0.34	0.48
CSFB	0.07	0.07	0.07	0.05	0.03	0.07	0.05	0.07	0.06	0.05	0.06	CSFB	0.20	0.20	0.31	1.00	0.26	0.40
Deutsche Bank	0.06	0.08	0.09	0.05	0.03	0.09	0.06	0.07	0.07	0.05	0.06	Deutsche Bank	0.18	0.20	0.21	0.24	1.00	0.36
Column average	0.08	0.09	0.08	0.06	0.03	0.09	0.06	0.07	0.07	0.06	0.07	Column average	0.38	0.41	0.40	0.43	0.41	0.41

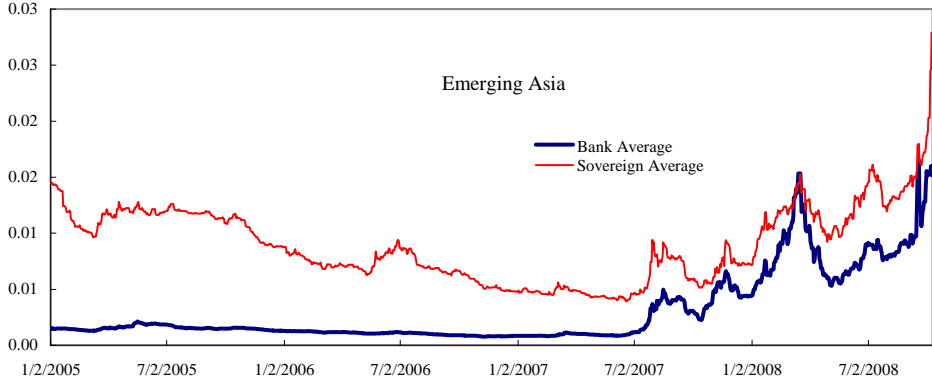
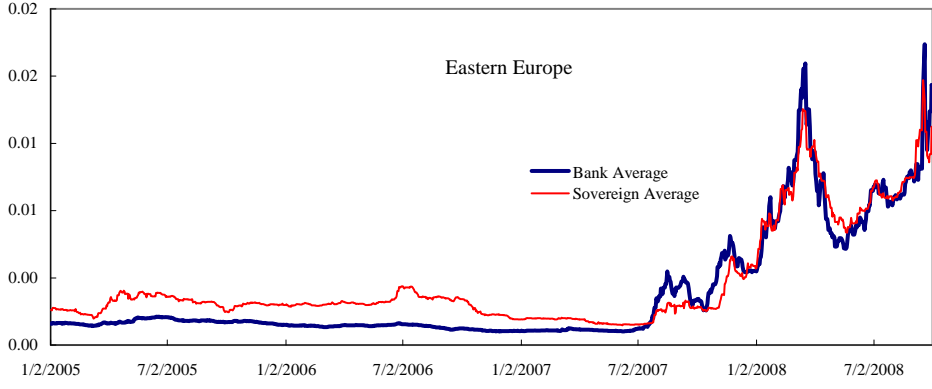
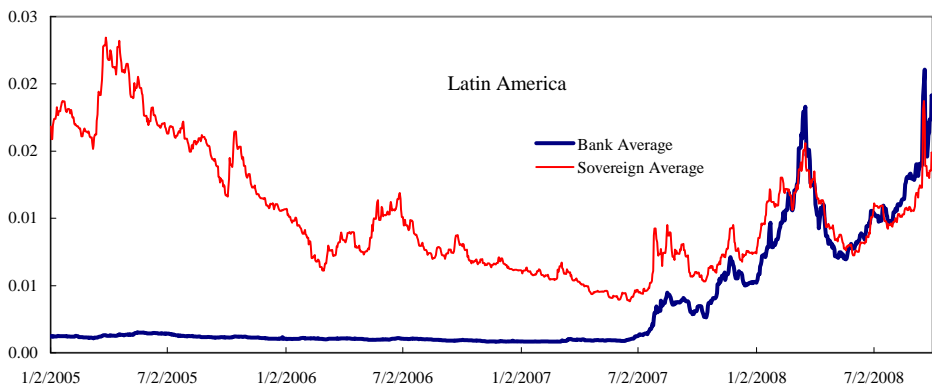
Source: Authors' calculations.

1/ Probability of distress of the bank in the row, conditional on the bank in the column becoming distressed.

Application 3:
Foreign Banks and Sovereigns:
Banking Systems with Cross-Border Institutions

Banking Systems with Cross-Border Institutions

Foreign Bank and Sovereign Risks



Perspective 2: Foreign Banks and Sovereigns

7/1/2007	BBVA	SAN	CITI	SCOTIA	HSBC	Row Average	MEXICO	COLOMBIA	BRAZIL	CHILE	Row Average	
BBVA	1.00	0.54	0.17	0.12	0.38	0.44	BBVA	0.13	0.08	0.08	0.23	0.13
SANTANDER	0.57	1.00	0.15	0.13	0.37	0.44	SANTANDER	0.14	0.08	0.09	0.24	0.14
CITI	0.18	0.16	1.00	0.21	0.18	0.34	CITI	0.14	0.05	0.08	0.15	0.10
SCOTIA	0.23	0.23	0.36	1.00	0.23	0.41	SCOTIA	0.22	0.10	0.13	0.23	0.17
HSBC	0.36	0.33	0.15	0.12	1.00	0.39	HSBC	0.12	0.07	0.07	0.19	0.11
<i>Column Average</i>	0.47	0.45	0.37	0.32	0.43	0.41	<i>Column Average</i>	0.15	0.07	0.09	0.21	0.13
	BBVA	SAN	CITI	SCOTIA	HSBC	Row Average	MEXICO	COLOMBIA	BRAZIL	CHILE	Row Average	
MEXICO	0.39	0.41	0.40	0.35	0.38	0.39	MEXICO	1.00	0.18	0.32	0.57	0.52
COLOMBIA	0.54	0.54	0.33	0.38	0.51	0.46	COLOMBIA	0.43	1.00	0.34	0.59	0.59
BRAZIL	0.52	0.56	0.47	0.44	0.48	0.49	BRAZIL	0.68	0.31	1.00	0.69	0.67
CHILE	0.25	0.26	0.16	0.14	0.23	0.21	CHILE	0.21	0.09	0.12	1.00	0.36
<i>Column Average</i>	0.43	0.44	0.34	0.33	0.40	0.39	<i>Column Average</i>	0.58	0.40	0.45	0.71	0.53
9/16/2008	BBVA	SAN	CITI	SCOTIA	HSBC	Row Average	MEXICO	COLOMBIA	BRAZIL	CHILE	Row Average	
BBVA	1.00	0.79	0.42	0.38	0.69	0.66	BBVA	0.47	0.39	0.42	0.61	0.47
SANTANDER	0.77	1.00	0.39	0.36	0.66	0.64	SANTANDER	0.46	0.38	0.42	0.62	0.47
CITI	0.75	0.73	1.00	0.68	0.75	0.78	CITI	0.73	0.53	0.63	0.75	0.66
SCOTIA	0.79	0.79	0.80	1.00	0.80	0.84	SCOTIA	0.80	0.63	0.71	0.82	0.74
HSBC	0.54	0.53	0.33	0.30	1.00	0.54	HSBC	0.36	0.29	0.30	0.41	0.34
<i>Column Average</i>	0.77	0.77	0.59	0.54	0.78	0.69	<i>Column Average</i>	0.56	0.44	0.50	0.64	0.54
	BBVA	SAN	CITI	SCOTIA	HSBC	Row Average	MEXICO	COLOMBIA	BRAZIL	CHILE	Row Average	
MEXICO	0.61	0.62	0.53	0.49	0.60	0.57	MEXICO	1.00	0.46	0.64	0.76	0.71
COLOMBIA	0.66	0.67	0.50	0.51	0.64	0.60	COLOMBIA	0.61	1.00	0.57	0.72	0.72
BRAZIL	0.61	0.63	0.52	0.50	0.57	0.57	BRAZIL	0.72	0.49	1.00	0.72	0.73
CHILE	0.35	0.37	0.24	0.22	0.30	0.30	CHILE	0.34	0.24	0.28	1.00	0.47
<i>Column Average</i>	0.56	0.57	0.45	0.43	0.53	0.51	<i>Column Average</i>	0.66	0.55	0.62	0.80	0.66

Source: Authors' calculations

These matrices present the probability of distress of the bank/sovereign in the row, conditional on the bank/sovereign in the column.

Perspective 2: Foreign Banks and Sovereigns

Distress Dependence Matrix: Eastern Europe

7/1/2007	INTESA	UNICREDITO	ERSTE	SOCIETE	CITI	Row Average		BULGARIA	CROATIA	HUNGARY	SLOVAKIA	Row Average
INTESA	1.00	0.37	0.20	0.29	0.12	0.40	INTESA	0.06	0.12	0.15	0.09	0.11
UNICREDITO	0.49	1.00	0.25	0.40	0.16	0.46	UNICREDITO	0.07	0.15	0.18	0.10	0.13
ERSTE	0.31	0.30	1.00	0.32	0.14	0.41	ERSTE	0.09	0.16	0.22	0.09	0.14
SOCIETE	0.30	0.32	0.21	1.00	0.13	0.39	SOCIETE	0.07	0.10	0.13	0.09	0.10
CITI	0.19	0.19	0.14	0.20	1.00	0.34	CITI	0.05	0.09	0.12	0.09	0.09
<i>Column Average</i>	0.46	0.43	0.36	0.44	0.31	0.40	<i>Column Average</i>	0.07	0.12	0.16	0.09	0.11
	INTESA	UNICREDITO	ERSTE	SOCIETE	CITI	Row Average		BULGARIA	CROATIA	HUNGARY	SLOVAKIA	Row Average
BULGARIA	0.10	0.09	0.10	0.11	0.06	0.09	BULGARIA	1.00	0.15	0.09	0.11	0.34
CROATIA	0.22	0.20	0.18	0.18	0.11	0.18	CROATIA	0.17	1.00	0.15	0.13	0.36
HUNGARY	0.36	0.32	0.33	0.29	0.18	0.30	HUNGARY	0.12	0.19	1.00	0.15	0.37
SLOVAKIA	0.07	0.06	0.04	0.06	0.04	0.06	SLOVAKIA	0.05	0.05	0.05	1.00	0.29
<i>Column Average</i>	0.19	0.17	0.16	0.16	0.10	0.16	<i>Column Average</i>	0.34	0.35	0.32	0.35	0.34
9/16/2008	INTESA	UNICREDITO	ERSTE	SOCIETE	CITI	Row Average		BULGARIA	CROATIA	HUNGARY	SLOVAKIA	Row Average
INTESA	1.00	0.52	0.40	0.53	0.25	0.54	INTESA	0.17	0.26	0.35	0.30	0.27
UNICREDITO	0.66	1.00	0.48	0.64	0.31	0.62	UNICREDITO	0.21	0.32	0.41	0.34	0.32
ERSTE	0.52	0.49	1.00	0.55	0.28	0.57	ERSTE	0.22	0.32	0.43	0.30	0.32
SOCIETE	0.46	0.44	0.37	1.00	0.23	0.50	SOCIETE	0.17	0.22	0.28	0.27	0.24
CITI	0.52	0.51	0.45	0.55	1.00	0.61	CITI	0.24	0.33	0.41	0.38	0.34
	INTESA	UNICREDITO	ERSTE	SOCIETE	CITI	Row Average		BULGARIA	CROATIA	HUNGARY	SLOVAKIA	Row Average
BULGARIA	0.34	0.32	0.33	0.37	0.22	0.32	BULGARIA	1.00	0.39	0.30	0.39	0.52
CROATIA	0.47	0.44	0.44	0.45	0.28	0.42	CROATIA	0.36	1.00	0.38	0.38	0.53
HUNGARY	0.45	0.42	0.43	0.43	0.26	0.40	HUNGARY	0.20	0.28	1.00	0.31	0.45
SLOVAKIA	0.13	0.12	0.10	0.14	0.08	0.12	SLOVAKIA	0.09	0.10	0.11	1.00	0.32
<i>Column Average</i>	0.35	0.32	0.33	0.35	0.21	0.31	<i>Column Average</i>	0.41	0.44	0.45	0.52	0.45

Source: Authors' calculations

These matrices present the probability of distress of the bank/sovereign in the row, conditional on the bank/sovereign in the column.

Perspective 2: Foreign Banks and Sovereigns

Distress Dependence Matrix: Asia

7/1/2007	HSBC	STDCHA	CITI	DEUT	BNP	DBS	JPMOR	Row Average		Korea	Malaysia	Thailand	China	Philippines	Indonesia	Row Average
HSBC	1.00	0.28	0.09	0.17	0.28	0.07	0.06	0.28	HSBC	0.05	0.04	0.03	0.05	0.01	0.02	0.03
STDCHA	0.21	1.00	0.06	0.13	0.23	0.05	0.05	0.25	STDCHA	0.05	0.05	0.03	0.04	0.02	0.02	0.03
CITI	0.10	0.09	1.00	0.13	0.12	0.03	0.23	0.24	CITI	0.03	0.03	0.02	0.03	0.01	0.01	0.02
DEUT	0.24	0.24	0.15	1.00	0.39	0.06	0.12	0.32	DEUT	0.05	0.06	0.04	0.05	0.02	0.02	0.04
BNP	0.21	0.22	0.08	0.21	1.00	0.05	0.06	0.26	BNP	0.04	0.04	0.03	0.04	0.01	0.01	0.03
DBS	0.07	0.07	0.03	0.05	0.08	1.00	0.02	0.19	DBS	0.14	0.13	0.07	0.05	0.03	0.05	0.08
JPMOR	0.11	0.11	0.39	0.16	0.14	0.04	1.00	0.28	JPMOR	0.04	0.04	0.03	0.05	0.01	0.02	0.03
Column Average	0.28	0.29	0.26	0.26	0.32	0.19	0.22	0.26	Column Average	0.06	0.05	0.04	0.04	0.02	0.02	0.04
	HSBC	STDCHA	CITI	DEUT	BNP	DBS	JPMOR	Row Average		Korea	Malaysia	Thailand	China	Philippines	Indonesia	Row Average
Korea	0.08	0.11	0.04	0.06	0.08	0.21	0.03	0.08	Korea	1.00	0.19	0.10	0.13	0.06	0.07	0.26
Malaysia	0.05	0.09	0.04	0.06	0.09	0.18	0.03	0.08	Malaysia	0.18	1.00	0.09	0.11	0.06	0.07	0.25
Thailand	0.11	0.15	0.07	0.09	0.13	0.23	0.06	0.12	Thailand	0.23	0.22	1.00	0.12	0.06	0.10	0.29
China	0.06	0.06	0.03	0.04	0.05	0.06	0.03	0.05	China	0.09	0.08	0.04	1.00	0.03	0.03	0.21
Philippines	0.15	0.23	0.11	0.18	0.20	0.27	0.08	0.17	Philippines	0.39	0.42	0.18	0.23	1.00	0.19	0.40
Indonesia	0.18	0.23	0.12	0.13	0.17	0.45	0.09	0.19	Indonesia	0.44	0.49	0.29	0.25	0.19	1.00	0.44
Column Average	0.11	0.15	0.07	0.09	0.12	0.23	0.05	0.12	Column Average	0.39	0.40	0.28	0.31	0.23	0.24	0.31
9/16/2008	HSBC	STDCHA	CITI	DEUT	BNP	DBS	JPMOR	Row Average		Korea	Malaysia	Thailand	China	Philippines	Indonesia	Row Average
HSBC	1.00	0.61	0.29	0.47	0.62	0.30	0.30	0.51	HSBC	0.29	0.27	0.25	0.31	0.16	0.18	0.24
STDCHA	0.54	1.00	0.25	0.42	0.57	0.27	0.26	0.47	STDCHA	0.29	0.28	0.25	0.28	0.17	0.18	0.24
CITI	0.67	0.65	1.00	0.69	0.70	0.40	0.80	0.70	CITI	0.40	0.42	0.37	0.44	0.27	0.29	0.37
DEUT	0.61	0.62	0.39	1.00	0.74	0.33	0.42	0.59	DEUT	0.32	0.34	0.28	0.33	0.21	0.21	0.28
BNP	0.52	0.55	0.25	0.48	1.00	0.26	0.27	0.48	BNP	0.25	0.26	0.22	0.26	0.15	0.16	0.22
DBS	0.49	0.51	0.29	0.41	0.51	1.00	0.29	0.50	DBS	0.60	0.59	0.49	0.46	0.32	0.41	0.48
JPMOR	0.51	0.51	0.59	0.55	0.55	0.30	1.00	0.57	JPMOR	0.29	0.31	0.27	0.34	0.19	0.21	0.27
Column Average	0.51	0.44	0.41	0.41	0.38	0.32	0.32	0.40	Column Average	0.35	0.35	0.31	0.35	0.21	0.23	0.30
	HSBC	STDCHA	CITI	DEUT	BNP	DBS	JPMOR	Row Average		Korea	Malaysia	Thailand	China	Philippines	Indonesia	Row Average
Korea	0.41	0.46	0.25	0.35	0.42	0.52	0.25	0.38	Korea	1.00	0.55	0.46	0.50	0.33	0.37	0.53
Malaysia	0.35	0.42	0.24	0.35	0.41	0.47	0.24	0.35	Malaysia	0.51	1.00	0.42	0.46	0.32	0.36	0.51
Thailand	0.33	0.38	0.21	0.29	0.35	0.40	0.21	0.31	Thailand	0.43	0.42	1.00	0.34	0.23	0.30	0.45
China	0.21	0.22	0.13	0.18	0.21	0.20	0.14	0.18	China	0.25	0.24	0.18	1.00	0.14	0.15	0.33
Philippines	0.38	0.46	0.28	0.38	0.42	0.46	0.26	0.38	Philippines	0.55	0.58	0.41	0.46	1.00	0.40	0.57
Indonesia	0.45	0.51	0.31	0.39	0.46	0.61	0.30	0.43	Indonesia	0.64	0.67	0.55	0.53	0.42	1.00	0.64
Column Average	0.36	0.41	0.24	0.32	0.38	0.44	0.23	0.34	Column Average	0.56	0.58	0.50	0.55	0.41	0.43	0.50

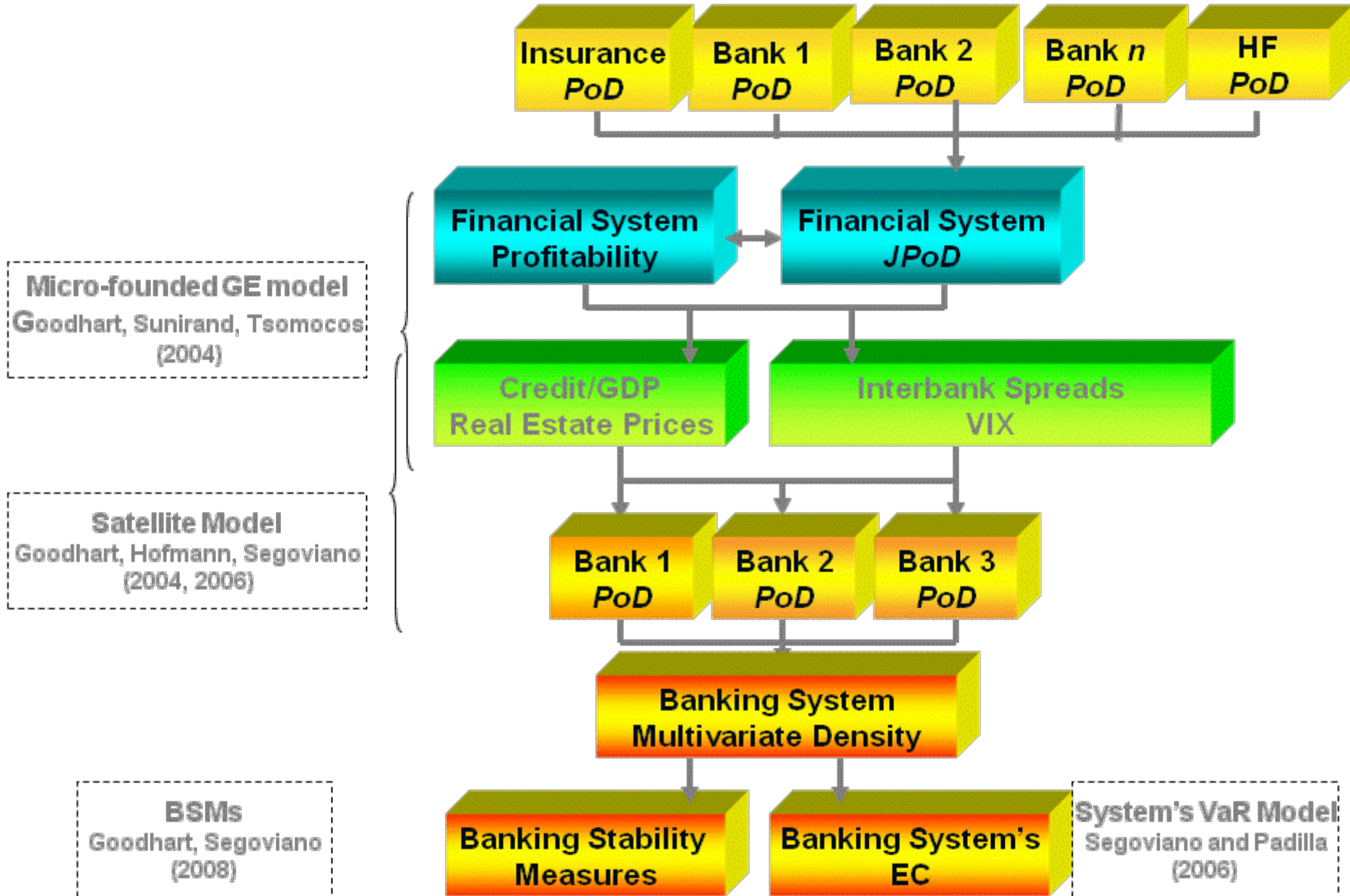
Source: Authors' calculations

These matrices present the probability of distress of the bank/sovereign in the row, conditional on the bank/sovereign in the column.

VI. Financial Stability Assessment Framework

Financial Stability Framework

(Athanasopolou, Ciu, Goodhart, Segoviano, Tsomocos, 2008)



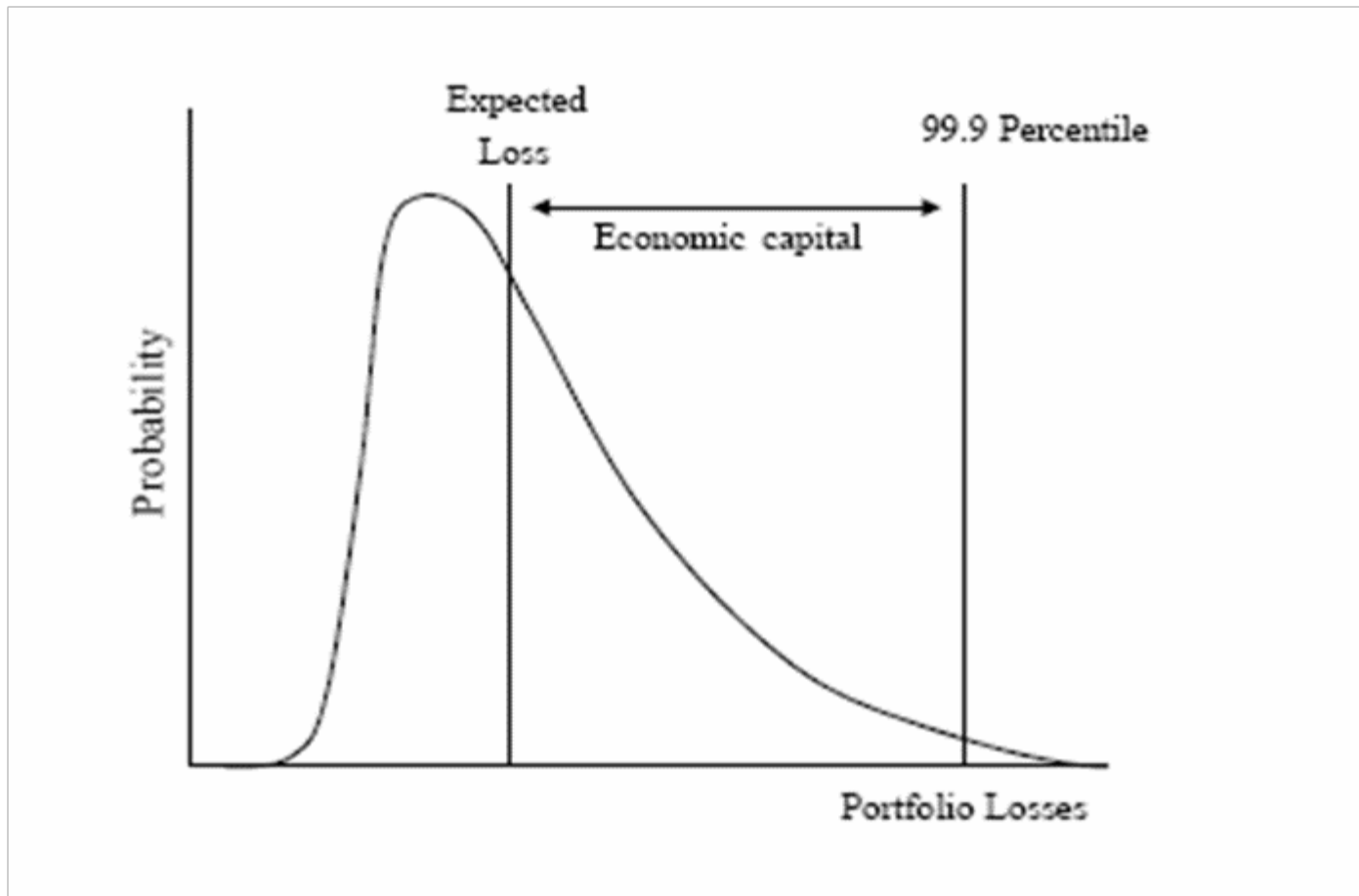
Conclusions

Provide a set of quantitative measures of financial stability

- 1. They can be constructed from very limited data (market indicators)**
- 2. Embed distress dependence (DD) among banks (and FI's when extended)**
- 3. Changes in DD consistent with the economic cycle**
- 4. Allow us to analyze stability from different angles**
- 5. This set of metrics will allow us to complement our research in FS**

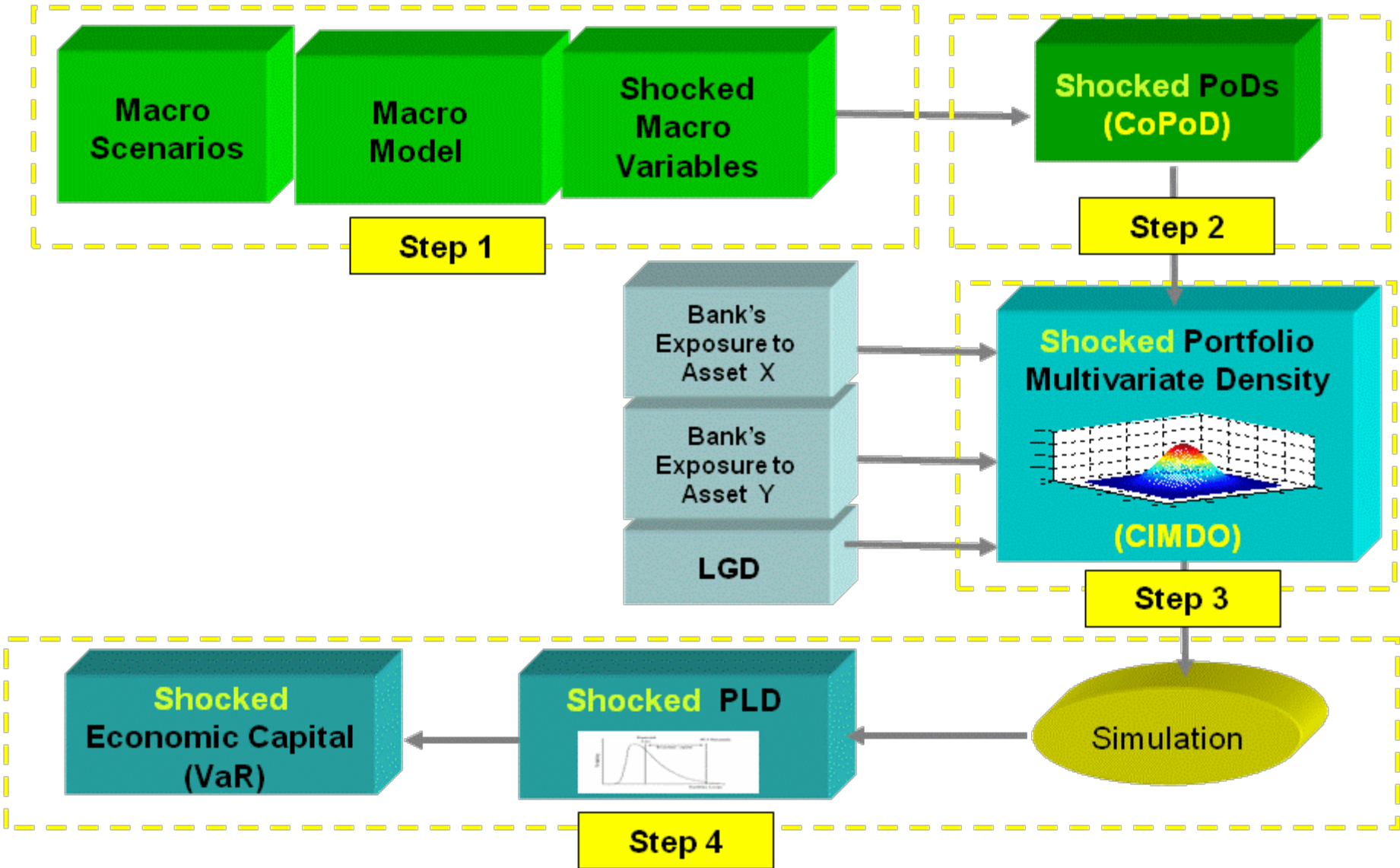
III. Macroeconomic Stress Testing

Expected and Unexpected Losses



**Pricing &
provisioning**

Macroeconomic Stress Test Procedure



Macroeconomic Scenarios

Scenario 1: Boom-bust in real estate prices and credit

Scenario 2: Foreign shock due to a correction of U.S. imbalances

Scenario 3: Boom-bust in real estate prices and credit plus increase in European interest rates

Macroeconomic Scenarios: Magnitudes

Variable	Baseline			Scenario 1			Scenario 2			Scenario 3		
	2006	2007	2008	2006	2007	2008	2006	2007	2008	2006	2007	2008
GDP % y/y	2.4	2.2	2.2	-1.8	-5	-6.8	-1.4	-3.2	-4.1	-2.4	-6.7	-9.2
Unemployment*	5.1	5	5	0.5	2.2	3.8	0.6	2	3.2	0.7	2.9	5.1
Private consumption % y/y	2.5	2.2	2.2	-2.8	-6.9	-9.1	0.4	-0.5	-1.2	-3.5	-8.8	-11.7
House price % y/y	7	3	3	-7.2	-17.8	-27	-0.6	-2.9	-5.5	-15.6	-29.8	-41.9
Business investment % y/y	5.9	4	4	-5.7	-12.6	-17.1	-1.8	-4.9	-7.7	-8	-19.5	-26.5
Exports % y/y	4.6	5.5	5.5	-2.4	-3.4	-3.1	-5.9	-8.3	-8.6	-3.3	-3.8	-3.1
Manufacturing output % y/y	3.5	3.2	3.2	-3.5	-9.7	-12.9	-3.6	-7.9	-9.9	-4.6	-13	-17.5
Consumer price % y/y	2.1	1.9	1.9	-0.1	-0.4	-0.8	-2	-3.1	-4	0.2	0	-0.4
Hourly wage % y/y	3.7	3.8	3.8	-0.1	-0.9	-2.7	-0.3	-1.5	-3.2	-0.1	-1.1	-3.5
Oil price \$/barrel	56.4	56.4	56.4	0	0	0	0	0	0	30	30	30
DKK/USD	638	638	638	0	0	0	-29	-29	-29	0	0	0
Bond yield % points	3.9	3.9	3.9	0	0	0	0	0	0	2.5	2.5	2.5
Discount rate % points	2.2	2.2	2.2	0	0	0	0	0	0	2.5	2.5	2.5
Share price % y/y	8	5	5	-0.7	-6.5	-11.5	-1.9	-9.6	-14.6	-23.7	-31.6	-30.8
Loans to private sector % y/y	8	5	5	-1.5	-7.0	-14.2	0	-1	-2.7	-1.8	-9.5	-19.5

* Percent of labour force national definition

PoDs Forecast

SECTOR	CREOVGDP		HOUP		GDP		UNEM		AVGR		MTGR		FXDU		R ²
	Sign	Lag	Sign	Lag	Sign	Lag	Sign	Lag	Sign	Lag	Sign	Lag	Sign	Lag	
Public sector	+	3	+	2			+	2					-	0	0.83
Agriculture	+	5	+	4	-	3							-	3	0.81
Fisheries	+	5	+	4			+	2	+	1					0.78
Manufacturing	+	4	+	1	-	1			+	0			-	2	0.74
Building	+	5	- , +	0, 5									-	3	0.68
Trade	+	4	-	0	-	3					+	0	-	0	0.72
Transport	-	1	-	0	-	0			+	0					0.69
Finance & insurance	-	0	+	3					+	0					0.73
Business Services	+	6	-	0	-	3									0.74
Households	+	4	-	0			+	1	+	1			-	2	0.71

PoDs Forecast: Manufacturing

	OLS	p-value	OLS S.E.	CoPoD	CoPoD S. E.	Var Difference (%)
C	3.2163	0.00	0.0130	3.2164	0.0081	155.0415%
CREOVGDP(-4)	0.9010	0.00	0.1614	0.9001	0.1312	51.1801%
HOUPL(-1)	0.5215	0.02	0.1811	0.5189	0.1309	91.5528%
GDP(-1)	-1.8838	0.00	0.3938	-1.8884	0.2920	81.8182%
AVGR(-0)	0.9701	0.02	0.3408	0.9712	0.2513	83.8742%
FXDU(-2)	-0.3140	0.06	0.1548	-0.3398	0.1116	92.3077%
R-squared		0.8425				
Adjusted R-squared		0.7441				

Sample: 1991-2005

Newey-West HAC Standard Errors & Covariance (lag truncation=2)

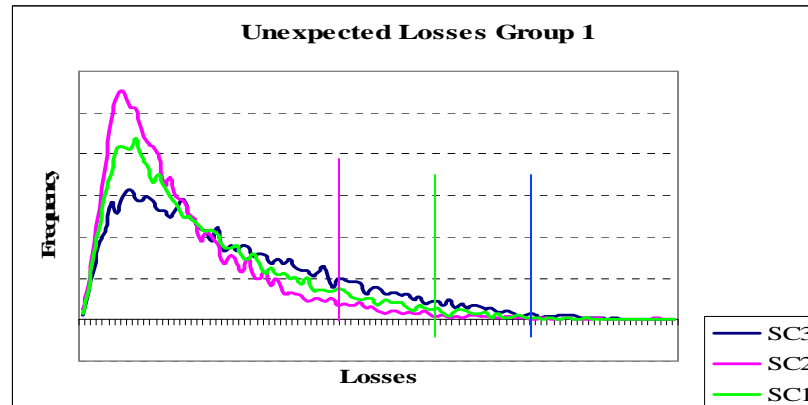
Expected Losses After Shock

EL	
Buffer/RWA	CAR
1.8088%	10.20%

	EXPECTED LOSSES		
	SCENARIO 1	SCENARIO 2	SCENARIO 3
2006	1.4054%	1.3074%	1.3044%
2007	1.6064%	1.6032%	2.0001%
2008	2.3018%	1.7034%	3.0072%

CAR After Shock

EL
Buffer/RWA CAR
1.8088% 10.20%



CAR After Shock

	Scenario1	Scenario2	Scenario3
2008	9.06	9.46	8.98
2009	7.91	8.23	7.02
2010	6.64	7.11	4.68

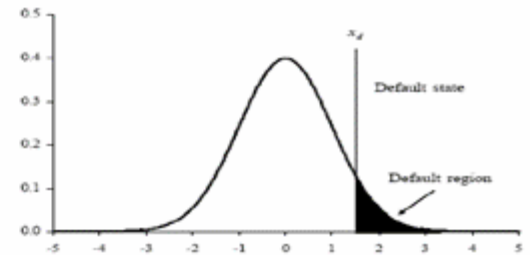
Backup Slides

CIMDO-density

The CIMDO density is recovered by minimizing the functional

$$\begin{aligned}
 L[p, q] = & \int \int p(x, y) \ln p(x, y) dx dy - \int \int p(x, y) \ln q(x, y) dx dy \\
 & + \lambda_1 \left[\int \int p(x, y) \chi_{[x_a^a, \infty)} dx dy - P_o D_t^x \right] \\
 & + \lambda_2 \left[\int \int p(x, y) \chi_{[x_a^y, \infty)} dy dx - P_o D_t^y \right] \\
 & + \mu \left[\int \int p(x, y) dx dy - 1 \right],
 \end{aligned}$$

Empirical
Information



CIMDO-copula

$$\widehat{p(x, y)} = q(x, y) \exp \left\{ - \left[1 + \widehat{\mu} + \left(\widehat{\lambda}_1 \chi_{[x_2^*, \infty)} \right) + \left(\widehat{\lambda}_2 \chi_{[x_2^*, \infty)} \right) \right] \right\}$$

$$c[u, v] = \frac{g[F^{(-1)}(u), H^{(-1)}(v)]}{f[F^{(-1)}(u)]h[H^{(-1)}(v)]}$$

$$c_c(u, v) = \frac{q[F_c^{-1}(u), H_c^{-1}(v)] \exp \left\{ - \left[1 + \widehat{\mu} \right] \right\}}{\int_{-\infty}^{+\infty} q[F_c^{-1}(u), y] \exp \left\{ - \widehat{\lambda}_2 \chi_{x_2^*}(y) \right\} dy \int_{-\infty}^{+\infty} q[x, H_c^{-1}(v)] \exp \left\{ - \widehat{\lambda}_1 \chi_{x_2^*}(x) \right\} dx}$$

Default Dependence

Some studies have used stock returns to calibrate Gaussian and T-copulas to estimate dependence of multivariate densities.

Drawbacks if objective is to model **default dependence**

- Does not include an explicit threshold beyond which decreases in stock returns are considered “default”.
- Correlation enters as a parameter in these densities
 - Measure of dependence in the center of the distribution,
not in the tail
 - Usually estimated across time; when we focus on static-spatial dependence at one point in time.

CIMDO-copula: Robustness

$$p(x, y) = p(x) \cdot p(y/x)$$

$$p(x, y) = p(y) \cdot p(x/y)$$

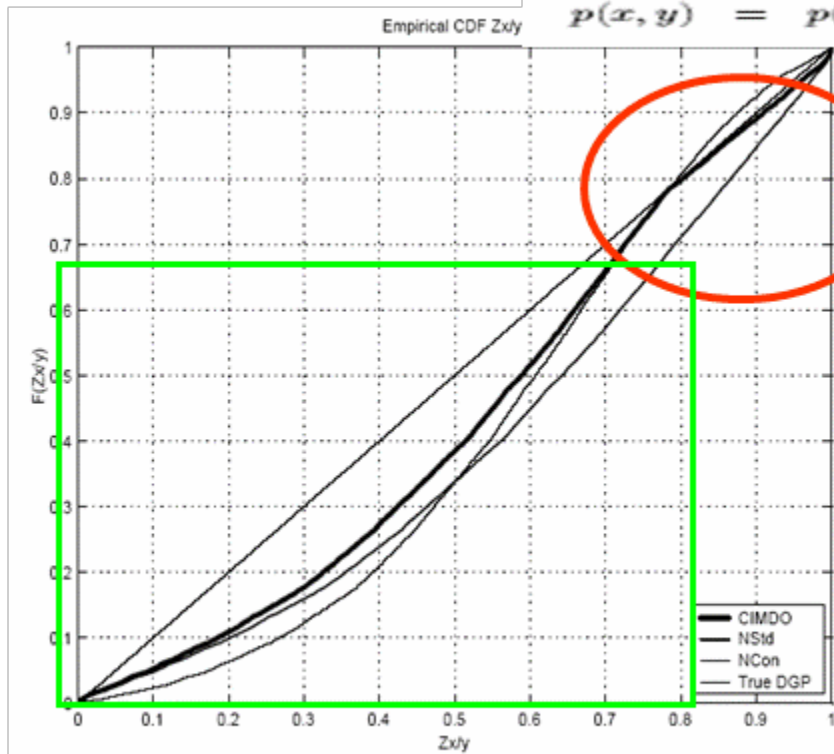


Figure 3-1: Empirical CDF $Z_{x/y}$: CIMDO, NStd, NCon

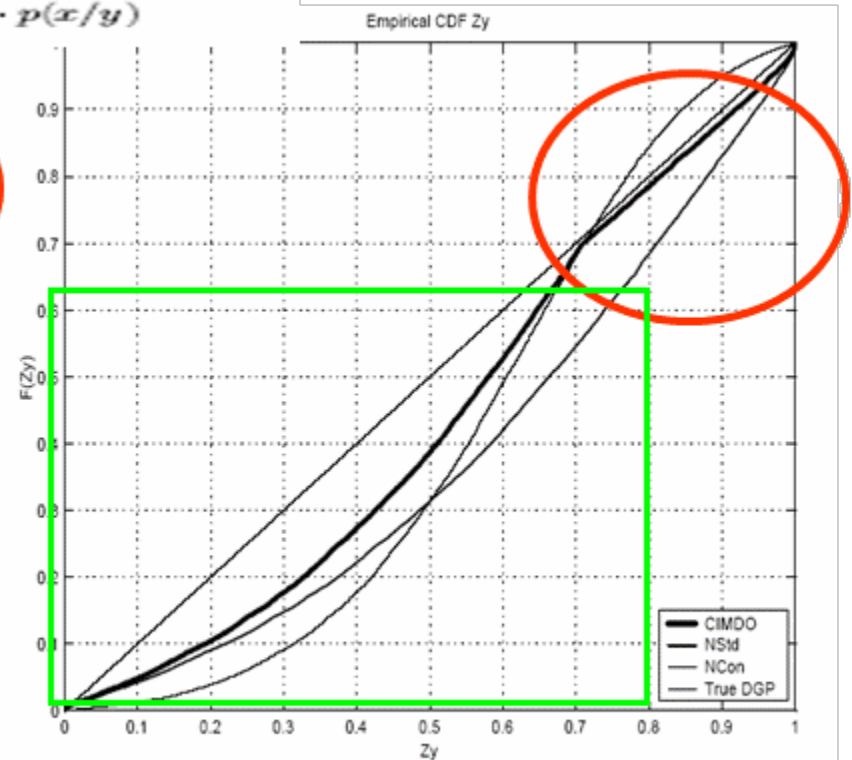


Figure 3-2: Empirical CDF Z_y : CIMDO, NStd, NCon

Default Dependence: Correlation

Why not correlation?

Adequate measure of dependence for spherical and elliptical distributions; e.g. multivariate normal distributions



Financial assets not represented by distributions of this class

Heavy tailed distributions might not even have finite variances

Data might be highly dependent while correlation is zero



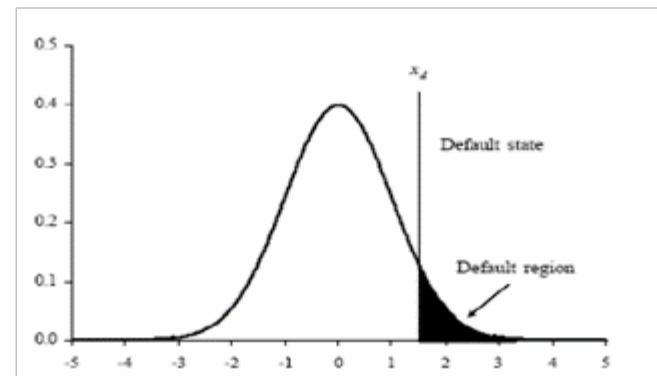
Independence implies zero correlation but not the opposite

Correlation is not invariant under non-linear transformations



$$\rho(T(X), T(Y)) \neq \rho(X, Y)$$

Measure of dependence in the center of the distribution. Gives little weight to tail events when evaluated empirically



Default Dependence: Copula Functions

Copula functions?

Describe linear and non-linear dependence of any type of distribution

Invariant under non-linear transformations



Same copula function:
Percentage returns or
logarithmic returns

Bivariate density provides
three sets of information



Information of Asset X
Information of Asset Y
Information of dependence
Structure

Sterilization of information of
marginals.

By transforming them into uniform
distributions



Hence left only with
dependence information

$$u = F(x), v = H(y)$$

Copula functions are multivariate
distributions whose marginals are
uniform on the interval [0,1]



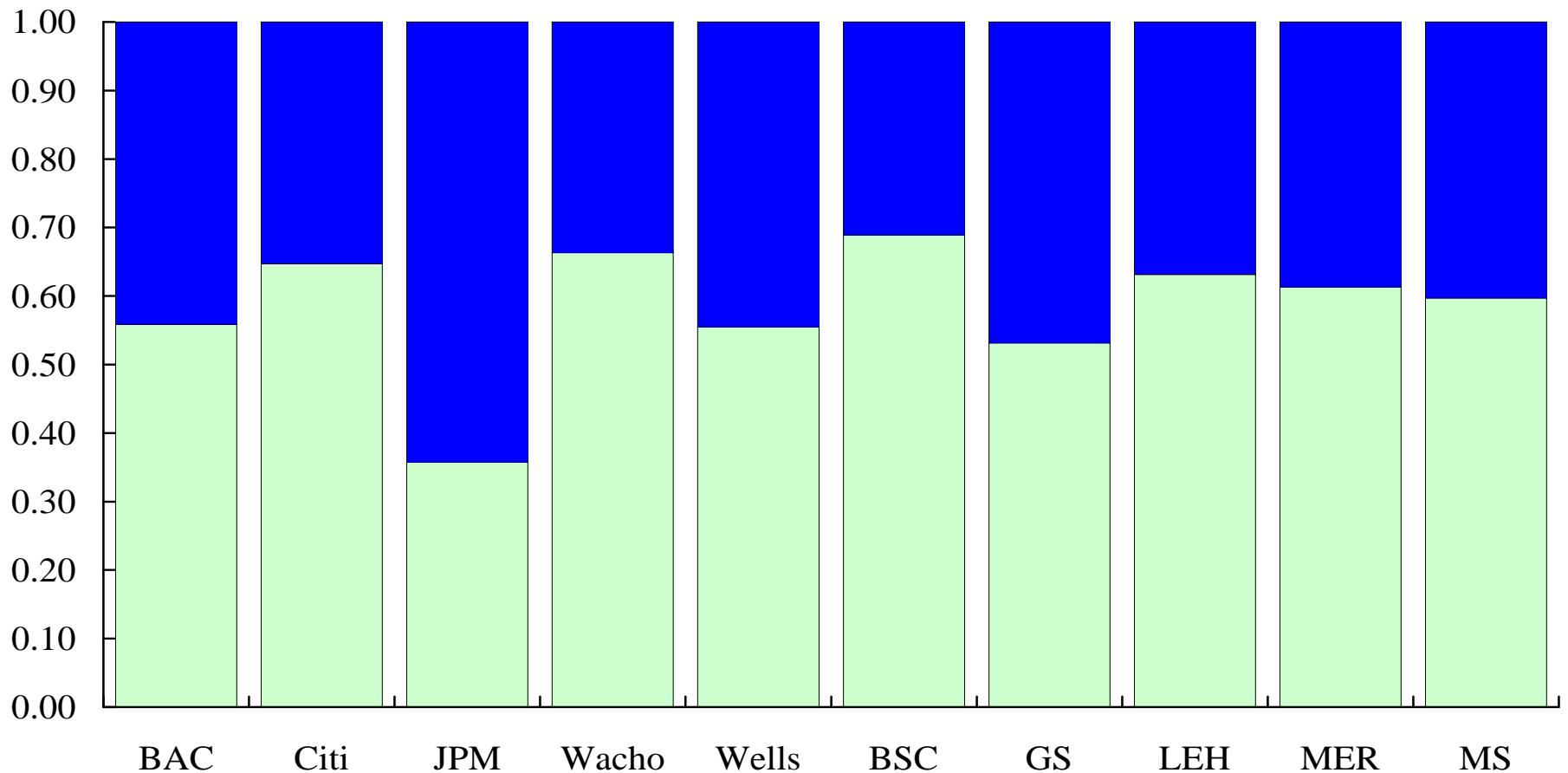
$$c[F(x), H(y)] = \frac{g[x, y]}{f[x]h[y]}$$

If variables are independent
Copula equals one

Using VIX to construct *Adjusted-CDS* spreads

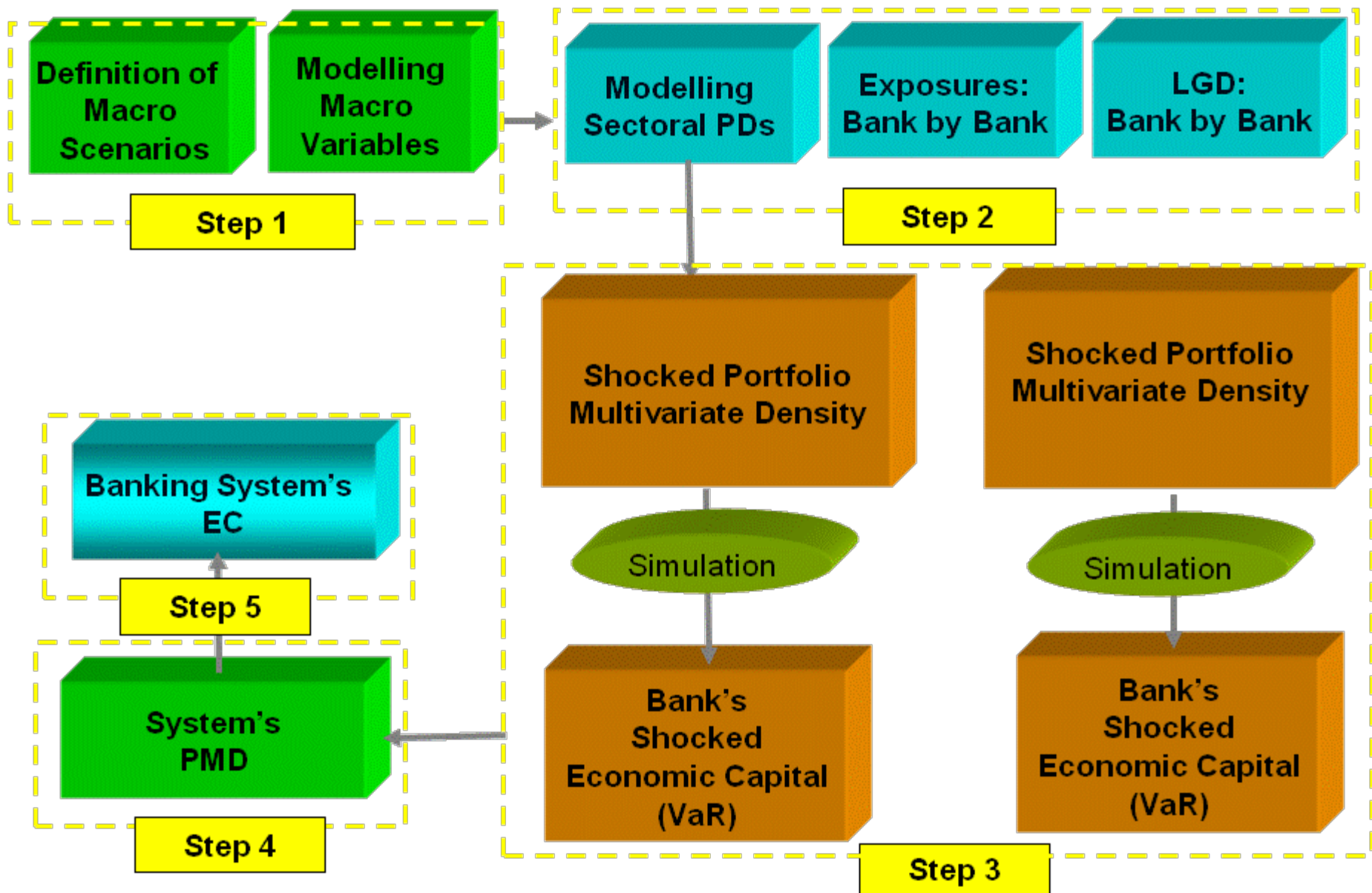
CDS Spreads and Market-wide Developments

■ CDS Not Explained by VIX Index ■ CDS Explained by VIX Index



Source: Authors' calculations.

Stress Testing with Loan Portfolio Information

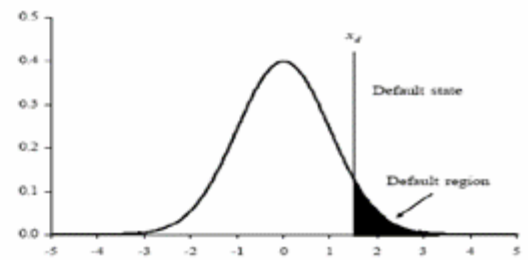


Portfolio Credit Risk: CIMDO-density

The CIMDO density is recovered by minimizing the functional

$$\begin{aligned}
 L[p, q] = & \int \int p(x, y) \ln p(x, y) dx dy - \int \int p(x, y) \ln q(x, y) dx dy \\
 & + \lambda_1 \left[\int \int p(x, y) \chi_{[x_a^a, \infty)} dx dy - P_0 D_t^x \right] \\
 & + \lambda_2 \left[\int \int p(x, y) \chi_{[x_a^y, \infty)} dy dx - P_0 D_t^y \right] \\
 & + \mu \left[\int \int p(x, y) dx dy - 1 \right],
 \end{aligned}$$

Empirical Information



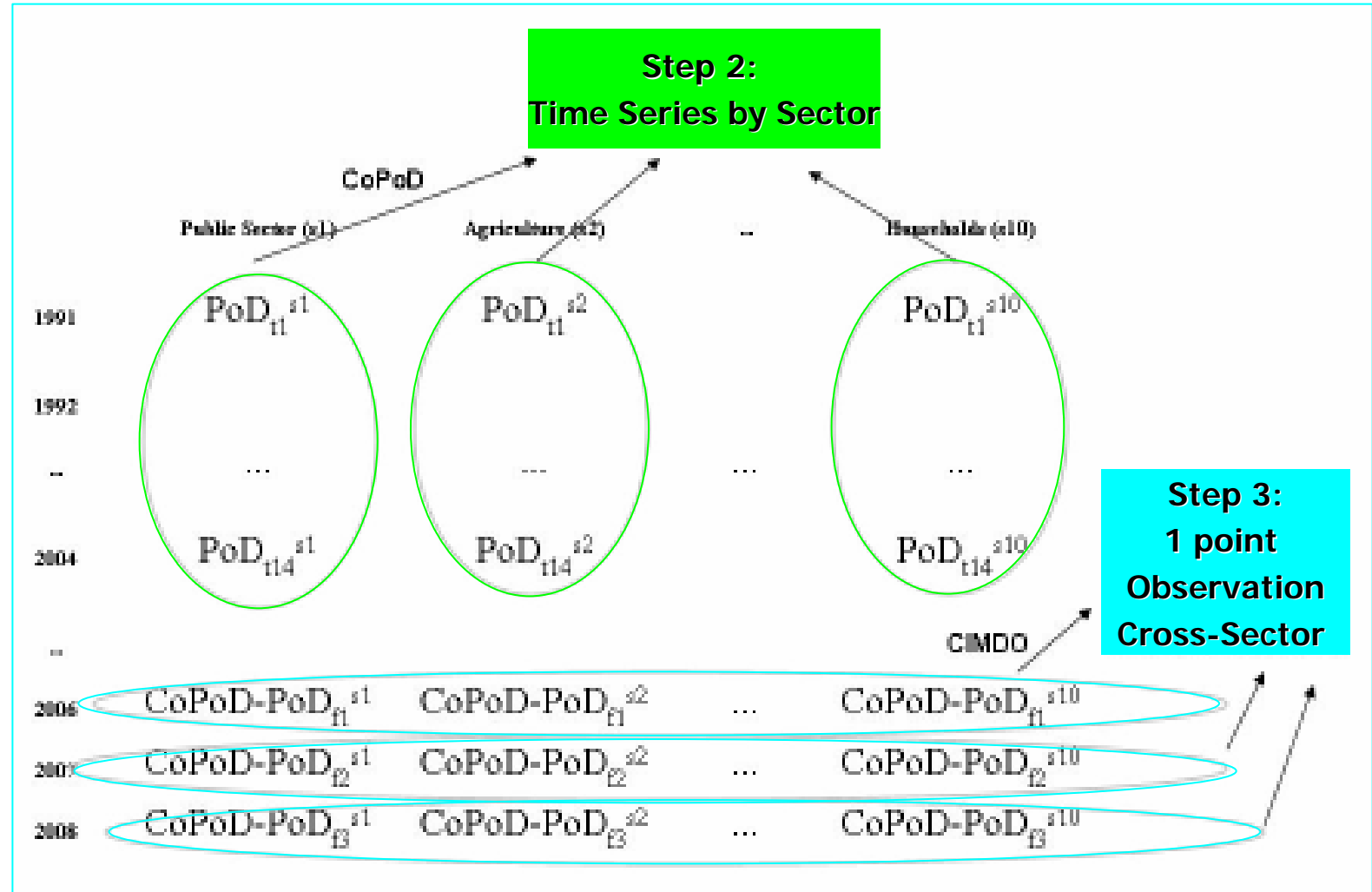
CIMDO-copula

$$\widehat{p(x, y)} = q(x, y) \exp \left\{ - \left[1 + \widehat{\mu} + \left(\widehat{\lambda}_1 \chi_{[x_2^*, \infty)} \right) + \left(\widehat{\lambda}_2 \chi_{[x_2^*, \infty)} \right) \right] \right\}$$

$$c[u, v] = \frac{g[F^{(-1)}(u), H^{(-1)}(v)]}{f[F^{(-1)}(u)]h[H^{(-1)}(v)]}$$

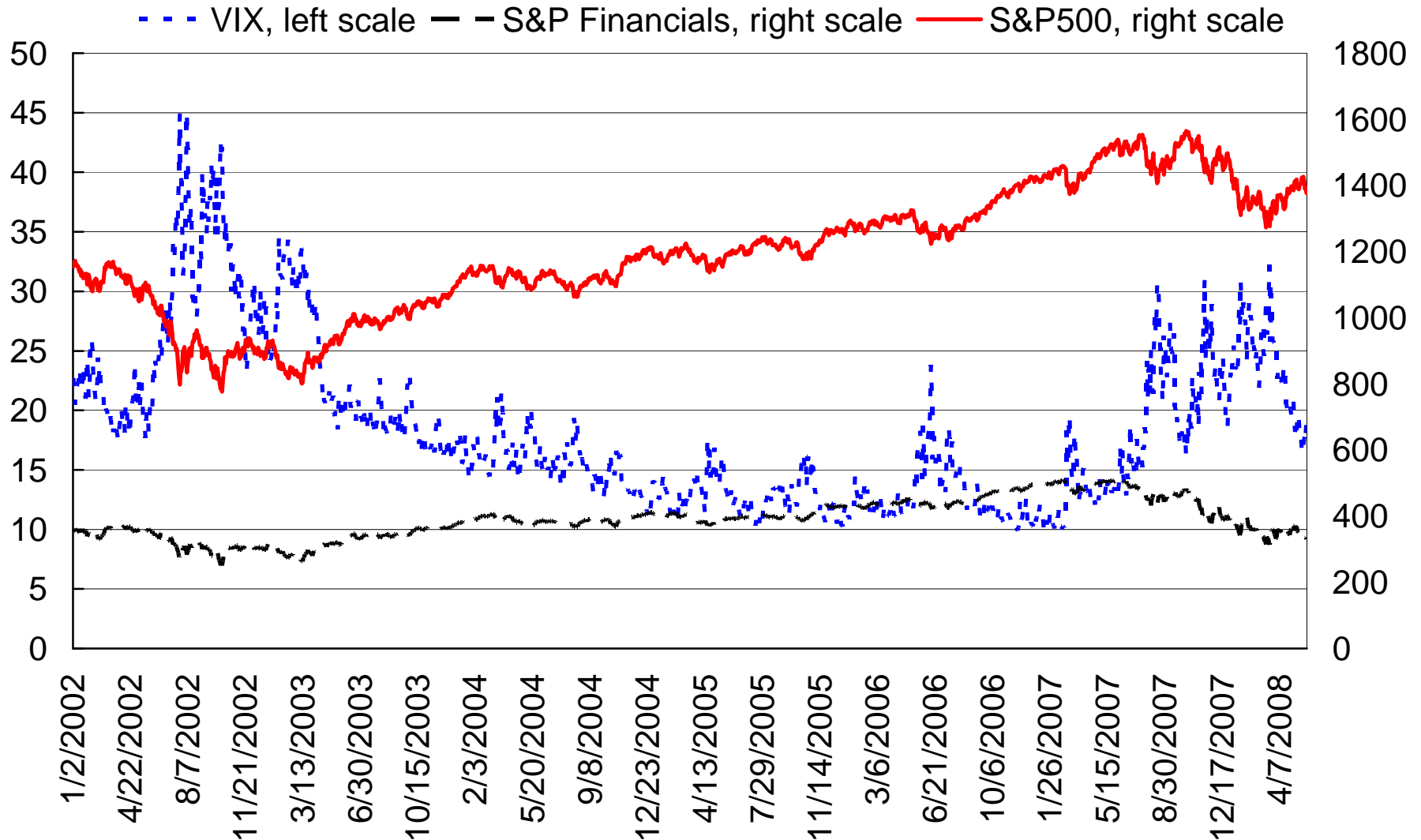
$$c_c(u, v) = \frac{q[F_c^{-1}(u), H_c^{-1}(v)] \exp \left\{ - \left[1 + \widehat{\mu} \right] \right\}}{\int_{-\infty}^{+\infty} q[F_c^{-1}(u), y] \exp \left\{ - \widehat{\lambda}_2 \chi_{x_2^*}(y) \right\} dy \int_{-\infty}^{+\infty} q[x, H_c^{-1}(v)] \exp \left\{ - \widehat{\lambda}_1 \chi_{x_2^*}(x) \right\} dx}$$

Information Requirements: Empirical Implementation



Increased Market-wide Volatility

Figure 1. Market-wide developments



Source: Bloomberg L.P.

Banking Stability Measures: Common Distress

1. Joint Probability of Distress (JPoD): $P(X \cap Y \cap R)$

$$\int_{x_0}^{\infty} \int_{y_0}^{\infty} \int_{r_0}^{\infty} p(x, y, r) dx dy dr = JPoD$$

2. Banking Stability Index (BSI)

Expected number of banks in distress given that at least one became distressed

Measure of conditional expectation of distress probability (Huang 1992)

$$BSI = \frac{P(X \geq x_0^*) + P(Y \geq x_0^*)}{1 - P(X < x_0^*, Y < x_0^*)}$$

Information Restrictions

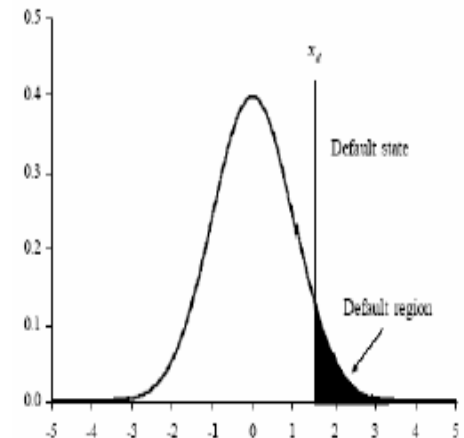
Through-time restrictions: Short time series of PoDs

- Omission of explicit incorporation of business cycle effects.
- Inefficient (large variances) estimators, due to small samples.

Point-in-time restrictions: Estimation of portfolio effects/default dependence

- Omission of portfolio/diversification effects.

Incorrect assessment of risk



The CoPoD (Segoviano, 2006a)

Through time restrictions.

- Produce **robust estimators** (vs. OLS regressions) **in the presence of short time series** of PoD's under the MSE.
- Framework to select significant **macroeconomic explanatory variables of Distress**. Based on theory and empirical evidence (Goodhart, Hofmann and Segoviano, 2004).

The CIMDO (Segoviano, 2006b)

Point in time restrictions.

- Allows to infer portfolio multivariate densities **from limited available** information.
- Generates **robust densities** under the PIT criterion (vs. most commonly used parametric densities for risk modeling).
- Embeds **changing dependence structure** consistent with economic cycle.