New Framework for Macrofinancial Risk Analysis, Financial Stability, and Integrating Financial Sector into Monetary Policy Models

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Outline

PART I   Contingent Claims Analysis (CCA) Framework

- **Basics of CCA**
- **Risk Transmission in Economy-wide CCA Interlinked Balance Sheets**

PART II   Application of CCA to Financial Institutions

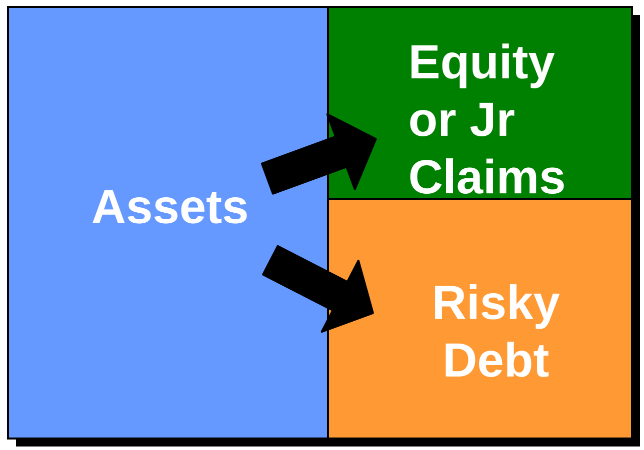
- **Moody's-KMV Model / Drivers of CDS spreads**
- **CCA models using Equity Options**
- **Impact of Financial Guarantees**

Based on papers Gray, Merton and Bodie in: (i) JOIM (2007), (ii) NBER and HBS (2007/08); and (iii) CCA of Subprime Crisis (2008) and *Macrofinancial Risk Analysis* book (Gray and Malone)

PART III Integrating CCA Models into Monetary Policy Models

Based on paper Gray, Restrepo, Luna "Incorporating Financial Sector into Monetary Policy Models: Application to Chile

Core Concept: Merton Model/CCA for Firms and Banks



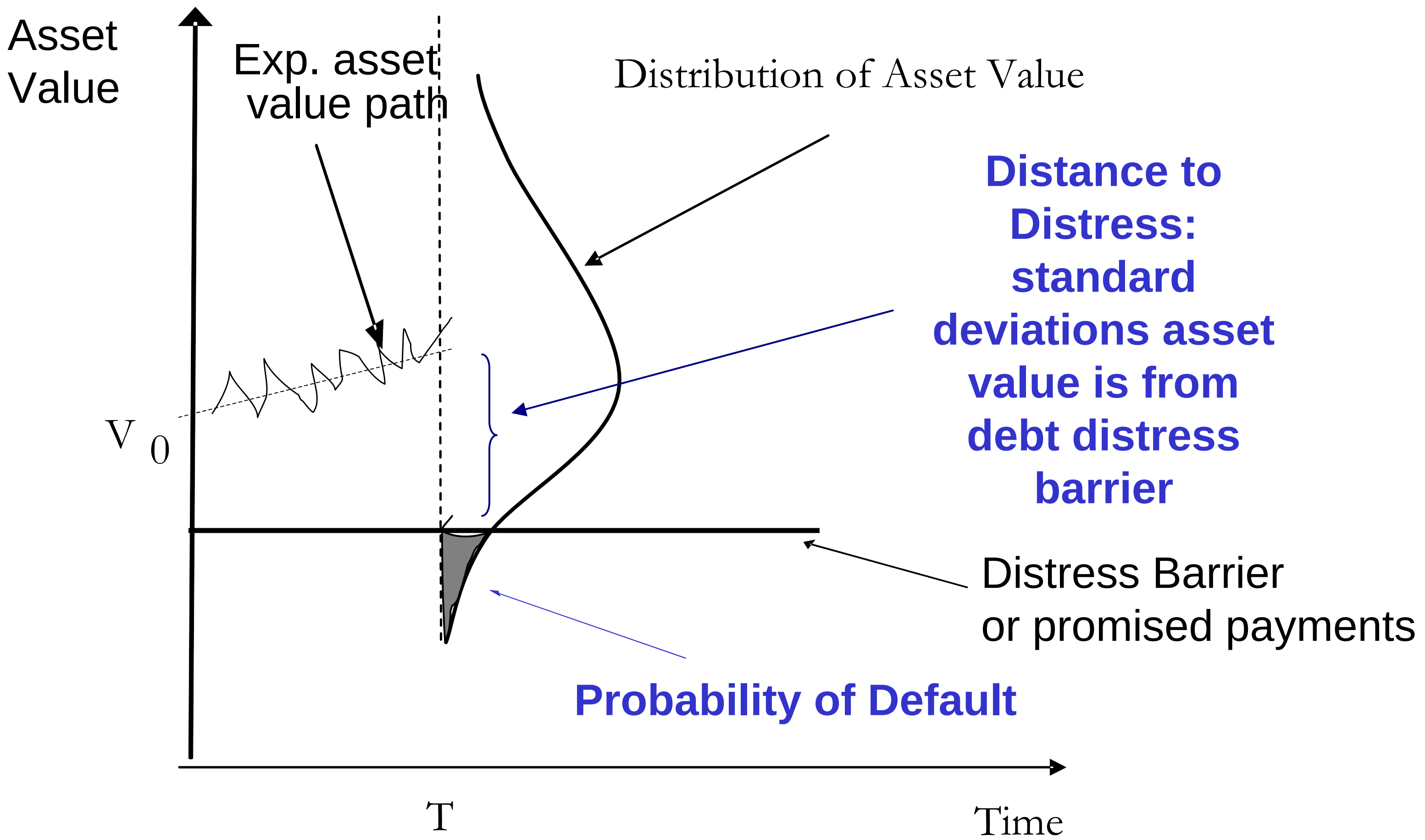
- Value of liabilities derived from value of assets.
- Liabilities have different seniority.
- Randomness in asset value.

Assets = Equity + Risky Debt

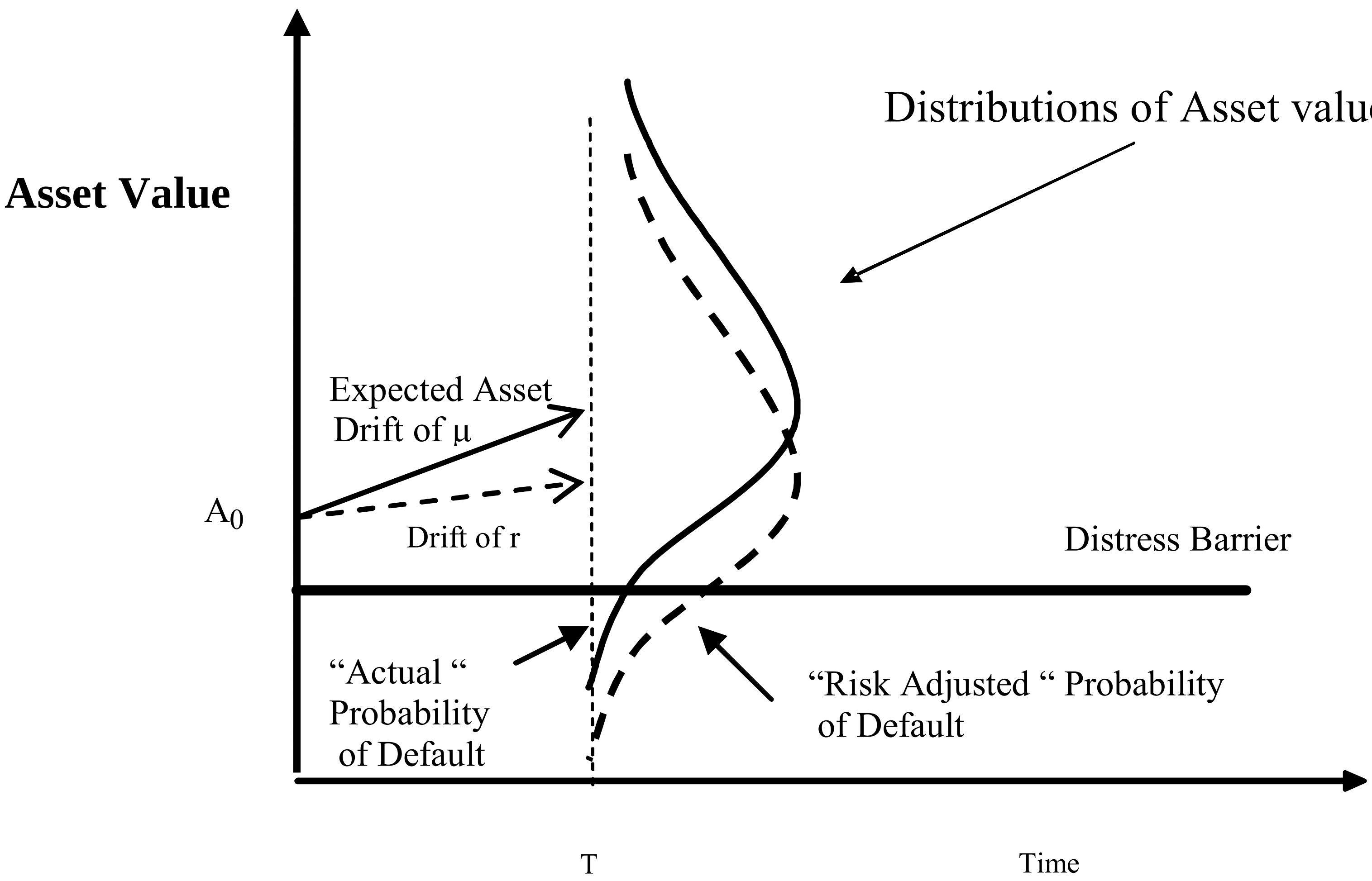
= Equity + Default-Free Debt – Expected Loss

= Implicit Call Option + Default-Free Debt – Implicit Put Option

CCA Credit Risk Measures



A Closer Look at Default - Difference Between Actual and Risk-Neutral Default Probability



$$\frac{\mu - r}{\sigma} = \rho_{A,M} SR$$

Calibrate (Unobservable) Market Value of Asset and Implied Asset Volatility

INPUTS

- Value and Volatility of Market Capitalization, E
- Debt Distress Barrier B (from Book Value)
- Time Horizon

USING TWO EQUATIONS WITH TWO UNKNOWNS

$$E = A\,N(d_1) - Be^{-rt}N(d_2)$$

$$E\sigma_E = A\sigma_A N(d_1)$$

Gives:

Implied Asset

Value A and

Asset Volatility σ_A

Default Probabilities

Spreads, Risk Indicators

KMV maps risk indicators to actual default probabilities (EDFs) using historical default data

Macrofinancial Risk Analysis is Applied at Bank, Sector, and Economy-wide Levels

CCA risk analysis tools can be applied to measure, analyze and manage risk for:

(i) Financial sector

- **Individual Institutions**
- **Aggregation of Institutions**

(ii) Household and Corporate Sectors

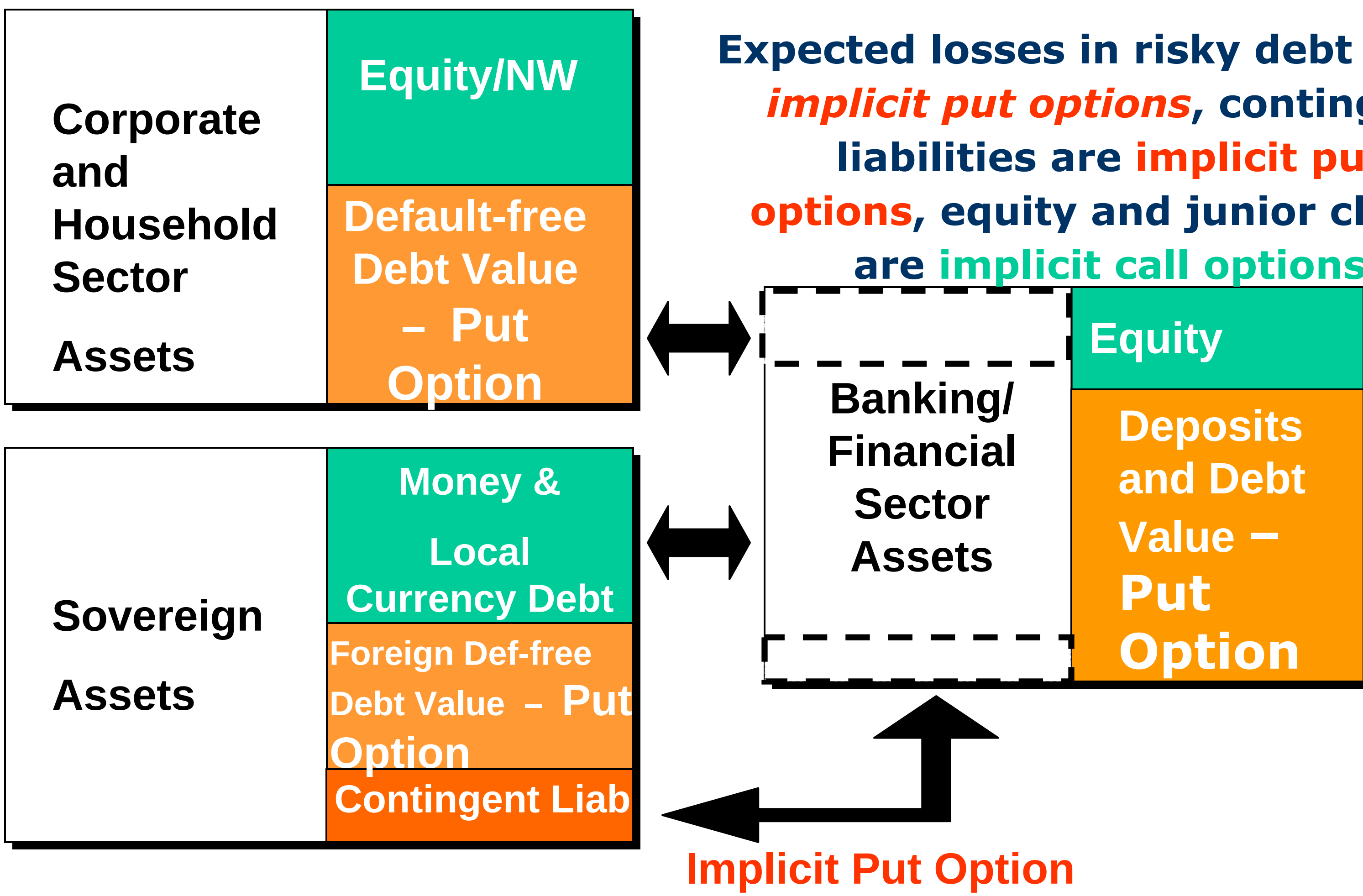
(ii) Sovereigns

(iv) Economy-wide Risk Framework

Sovereign, Bank, and Corporate and Household Economy-wide CCA Sector Interlinked Balance Sheets

Risky Debt = Default-free Value of Debt minus Expected Losses

Expected losses in risky debt are *implicit put options*, contingent liabilities are implicit put options, equity and junior claims are implicit call options



Calibrated CCA Balance Sheet: Assets Minus Liabilities equal Zero

For a sector, sub-sector or individual institution

CCA Balance Sheet

Assets

+or - Implicit or Explicit Guarantees {Implicit Put Options}

minus

Equity / Jr. Claim {Implicit Call Option}

minus

(Default-free Value of Debt – Implicit Put Option)

= 0

Illustrative Results Assets and Liabilities for Linked Sectors including Implicit Guarantees and Expected Losses in Risky Debt (6/2003)

CHILE - Hypothetical CCA Balance Sheet 2003 (billion US$)				
	Sovereign	Banking Sector	Non-Bank Financial	Corporate
Asset	26.39	69.69	65.47	82.67
Implicit Guarantee	-0.261	0.05	0.19	0.02
Asset plus Guarantee	26.13	69.74	65.65	82.69
Jr Claim or Equity	6.01	25.73	17.17	52.70
Default-free Debt Value	20.15	44.02	48.55	30.06
Expected Loss	0.03	0.01	0.06	0.07
Risky Debt (Default-free - EL)	20.12	44.01	48.48	29.99
Sector Assets minus Liabilities*	0.00	0.00	0.00	0.00
**Equals Asset + Guarantee - Jr Claim - (Default-free Value of Debt minus Expected Loss)*				
5-yr Est Actual Sovereign Spread	65	bps		

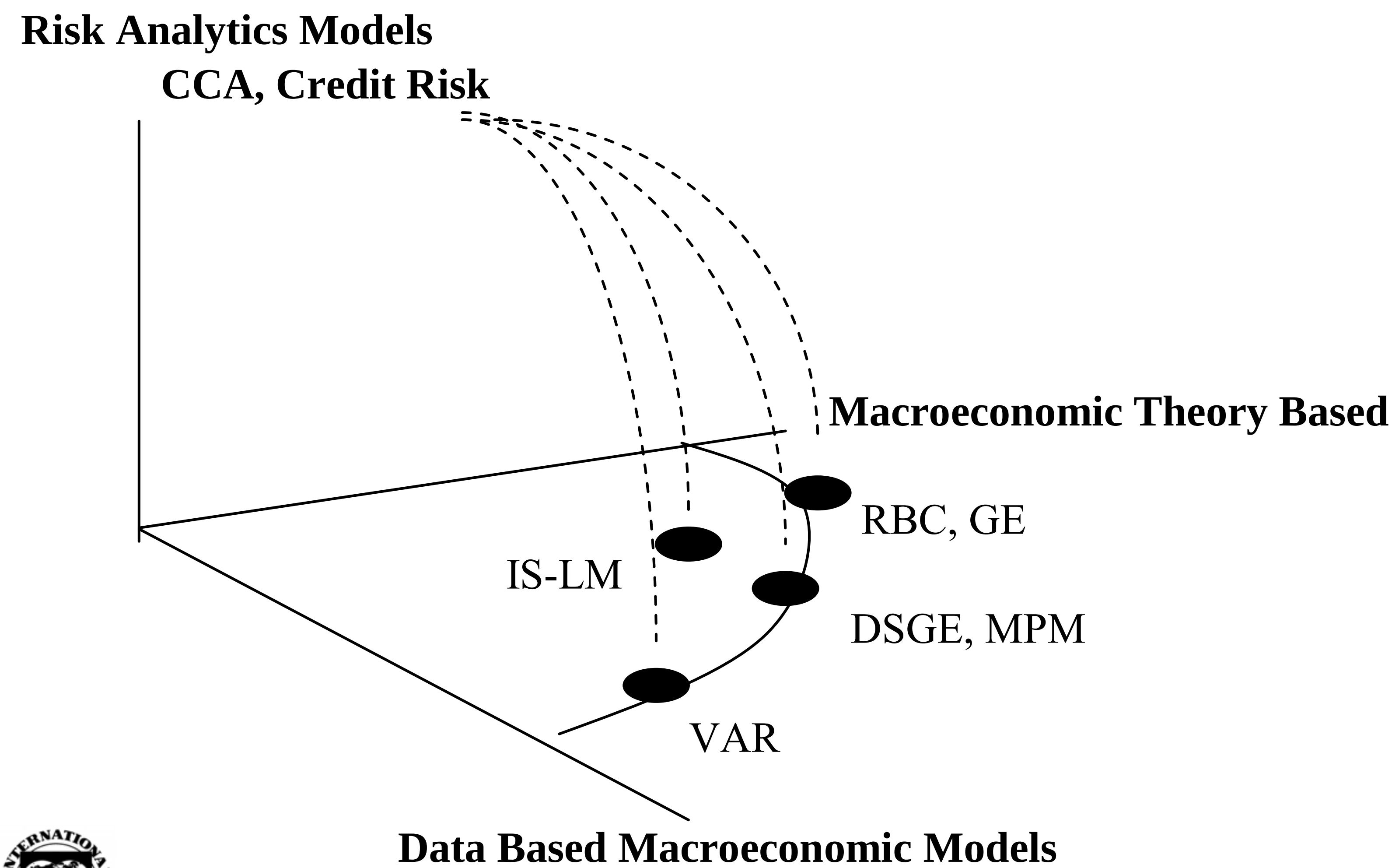
Economy-wide CCA Balance Sheet Models Capture Non-linear Risk Transmission

- Note that if asset volatility in CCA sector balance sheets is set to zero:
  - Implicit put options go to zero,
  - Macroeconomic accounting balance sheets and traditional flow-of-funds are the result
  - Measurement of (non-linear) risk transmission is not possible using macroeconomic flow or accounting frameworks
- Interlinked implicit options result in compound options that exhibit highly non-linear risk transmission, as seen a variety of financial crises

Linking CCA Balance Sheet Models to Macroeconomic Flows and Models

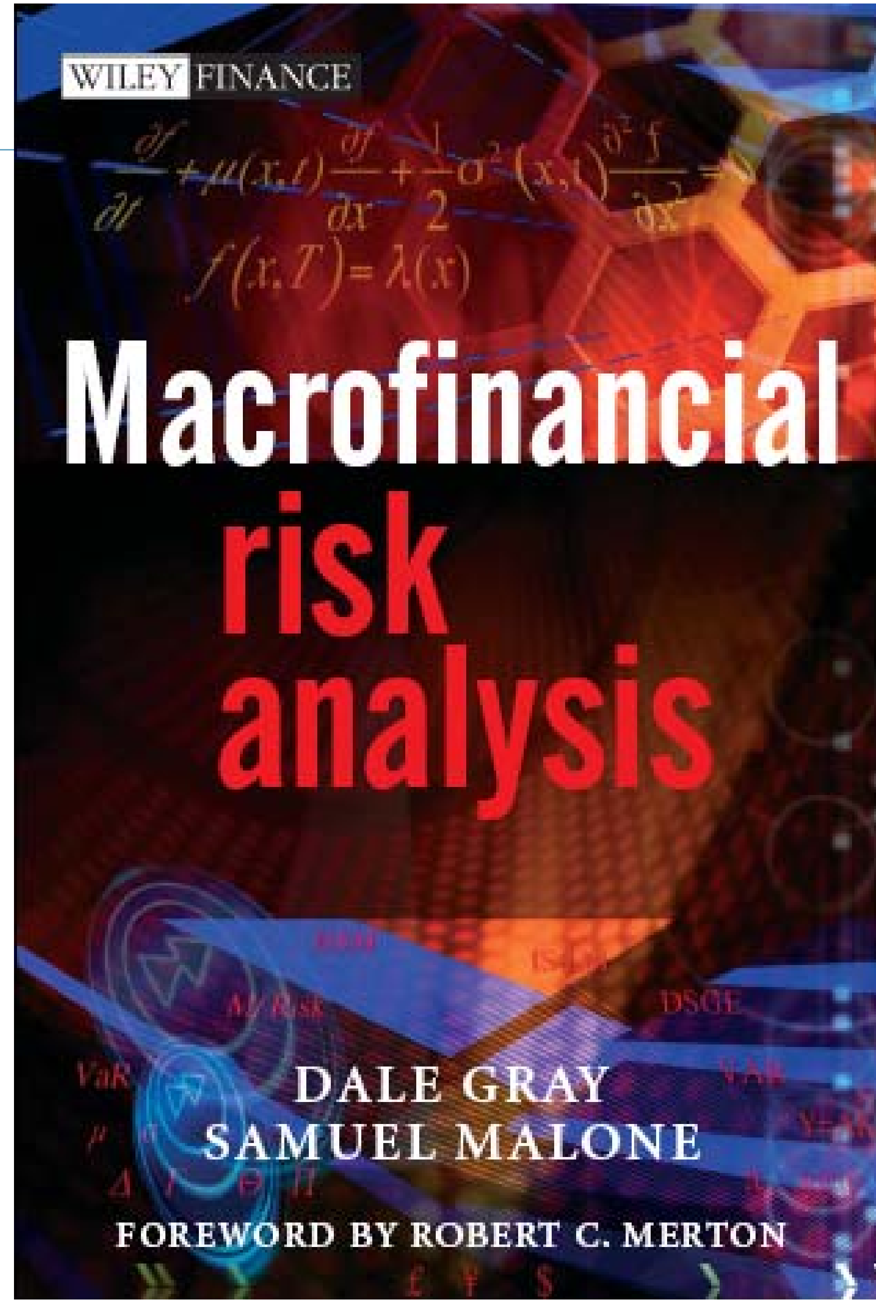
- **Macroeconomic models geared to try to forecast the mean of macro variables (i.e. first moment)**
- **Finance measures risk from stochastic assets relative to threshold (second and third moments critical to risk indicators).**
- **CCA is an excellent tool for analyzing financial stability**
- **Time pattern of CCA risk indicators can be linked to macroeconomic variables and to monetary policy models**

Added Dimension of Risk Indicators CCA Risk Analytics Models to Spectrum of Macroeconomic Models



Macrofinancial Risk Analysis

- **Framework integrates risk-adjusted balance sheets using Contingent Claims Analysis (CCA) of financial institutions, corporates, and sovereigns together and with macroeconomic and monetary policy models**
- **TOOLKIT FOR MACRO RISK ANALYSIS**



Enhanced CCA/Structural Models Financial Institutions

- **Using Enhanced CCA/Structural models**
  - **Drivers of CDS Spreads - Moody's-KMV Expected Default Frequencty (EDF) and EDF Implied CDS**
  - **Using equity options to calibrate higher moments of implied asset distribution and model risk**
  - **Systemic Risk - fire sale/MTM risk, asset illiquidity in CCA models**
- **Financial CCA with Factor Model for Stress-testing**
- **Minimum Capital vs Default**
- **Measuring government financial guarantees using equity market and CDS data in a CCA model (GSEs)**

MKMV Key Drivers of Expected Default Frequency (EDF) and EDF Implied CDS spreads (EICDS)

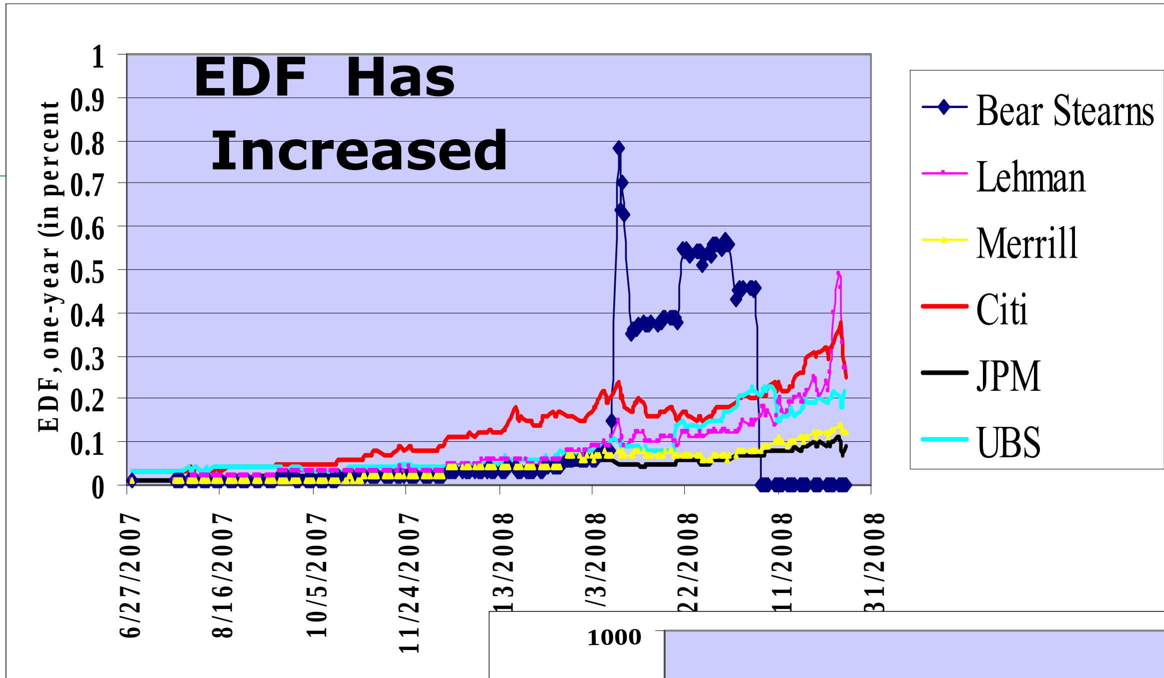
EDF Key Drivers are Market Leverage (default point divided by assets) and asset volatility

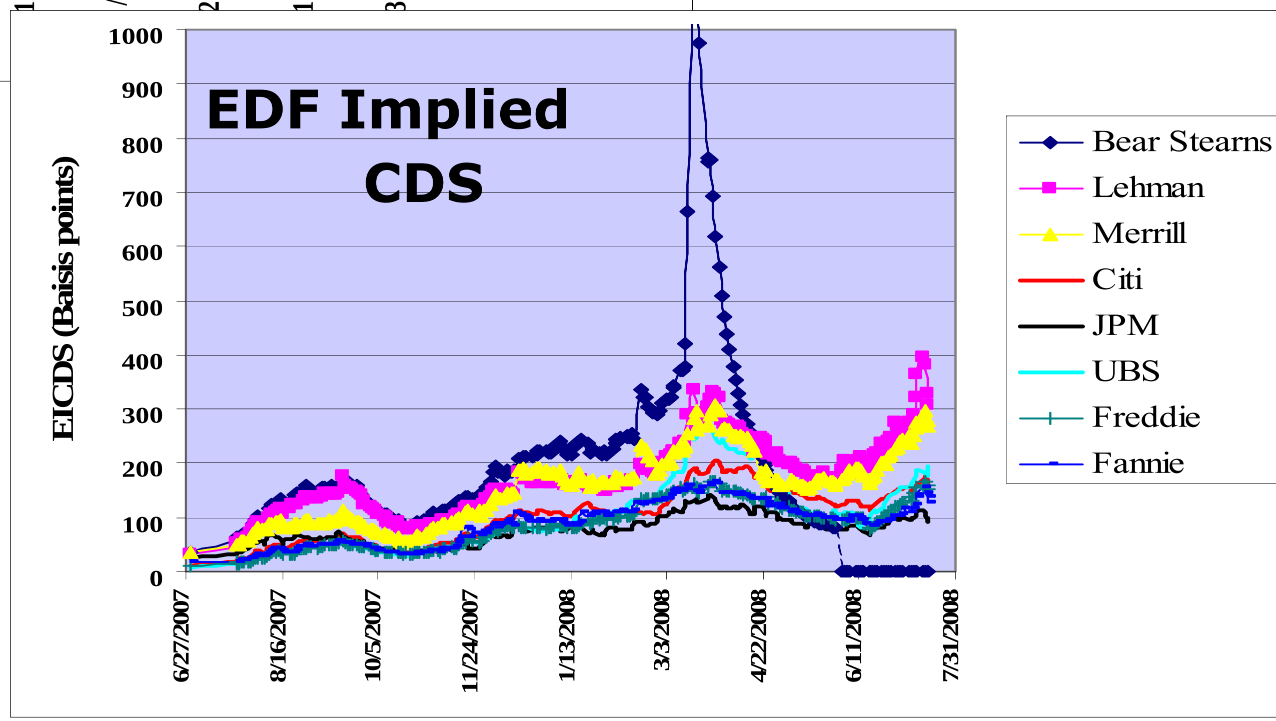
$$EDF = f\left(L_{Mkt\,Leverage}, \sigma_{Asset}, other\right)$$

Key Drivers of EICDS are Risk-Neutral EDF (from EDF, Market Sharpe Ratio (SR), correlation ρ) and Loss Given Default

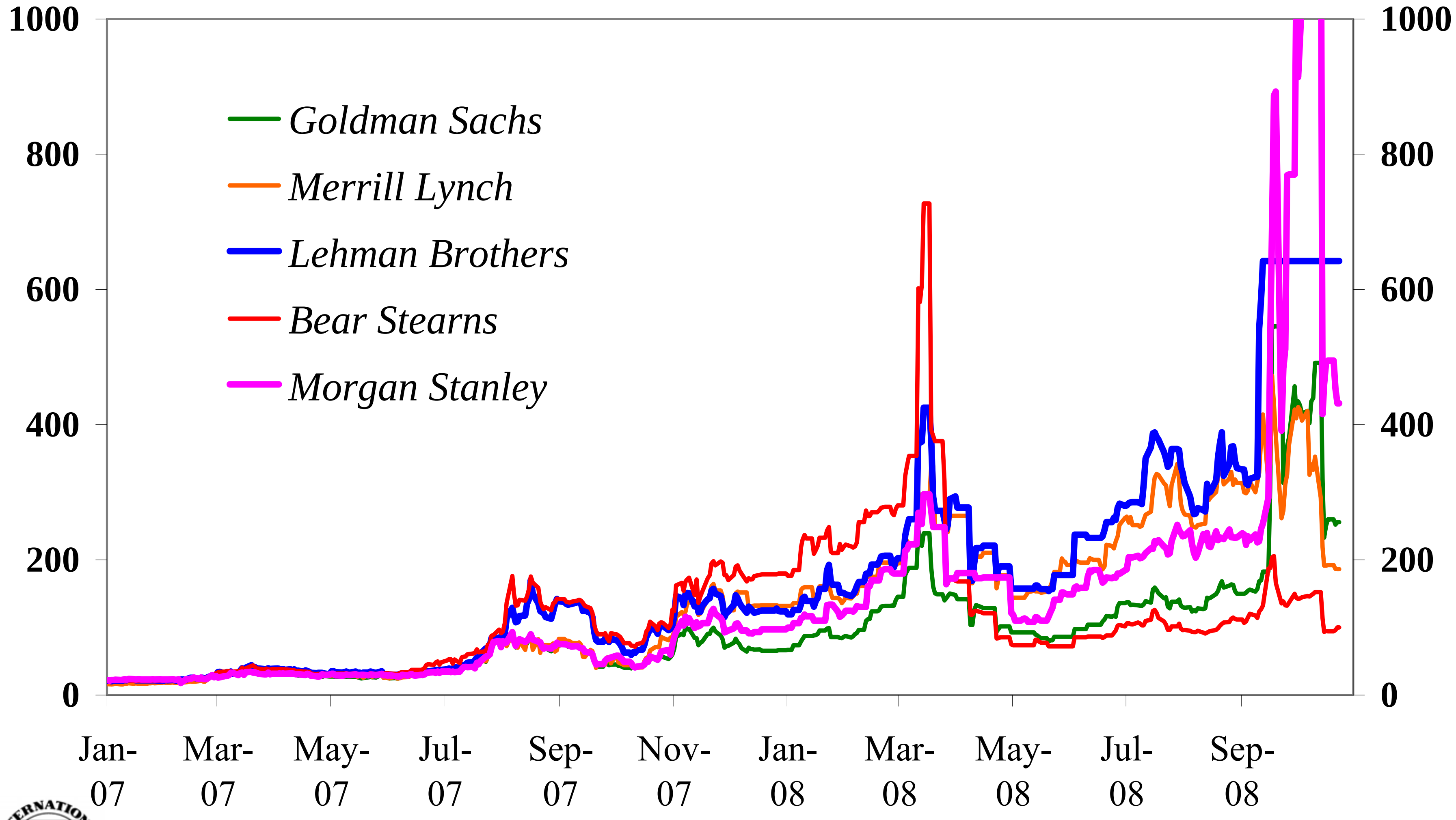
$$EDF_{Risk-Neutral} = f\left[EDF, \rho_{A,Mkt}, SR\right]$$

$$EICDS = -\frac{1}{T}\ln\left(1 - LGD_{Risk-Neutral} * EDF_{Risk-Neutral}\right)$$

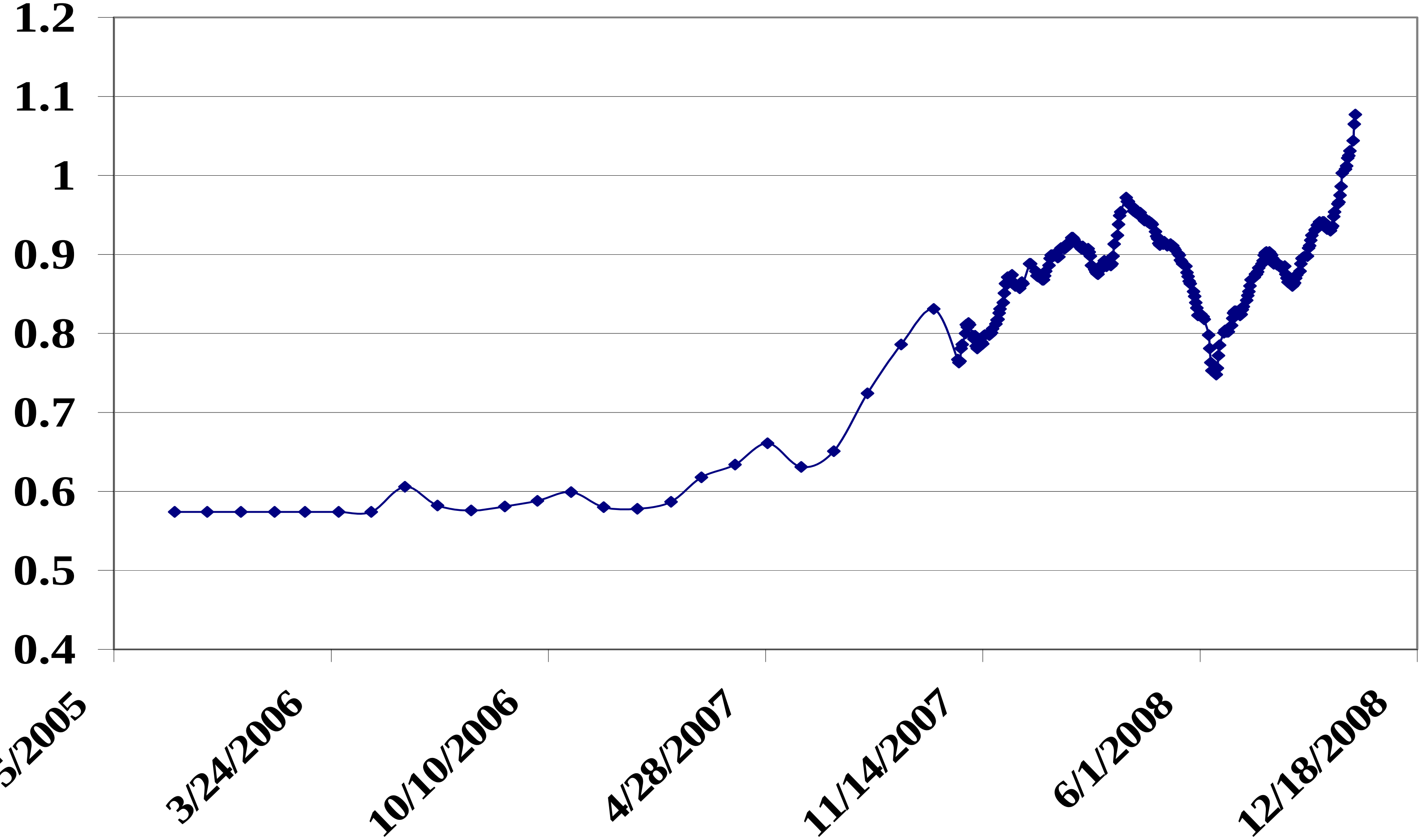

EDF Has
Increased
EDF, one-year (in percent
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0
6/27/2007
8/16/2007
10/5/2007
11/24/2007
Bear Stearns
Lehman
Merrill
Citi
JPM
UBS


EDF Implied
CDS
EICDS (Baisis points)
1000
900
800
700
600
500
400
300
200
100
0
6/27/2007
8/16/2007
10/5/2007
11/24/2007
1/13/2008
3/3/2008
4/22/2008
6/11/2008
7/31/2008
Bear Stearns
Lehman
Merrill
Citi
JPM
UBS
Freddie
Fannie

CDS for Investment Banks (bps)



Significantly Higher Market Sharpe Ratio since July 2007, with peaks on 3/27/08, 8/6/08 and 10/23/08

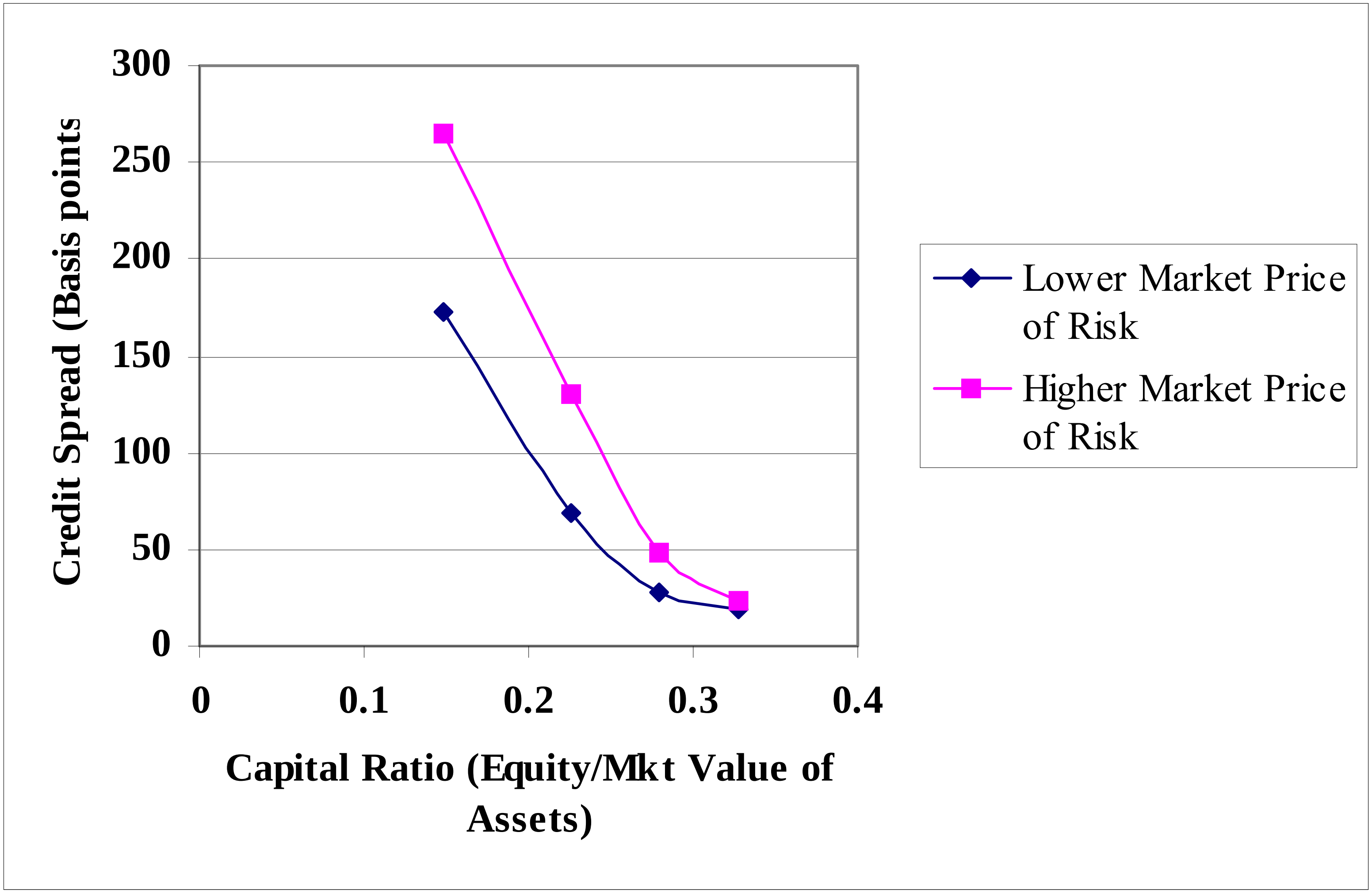


Market Sharpe Ratio and other indicators show decreased risk appetite

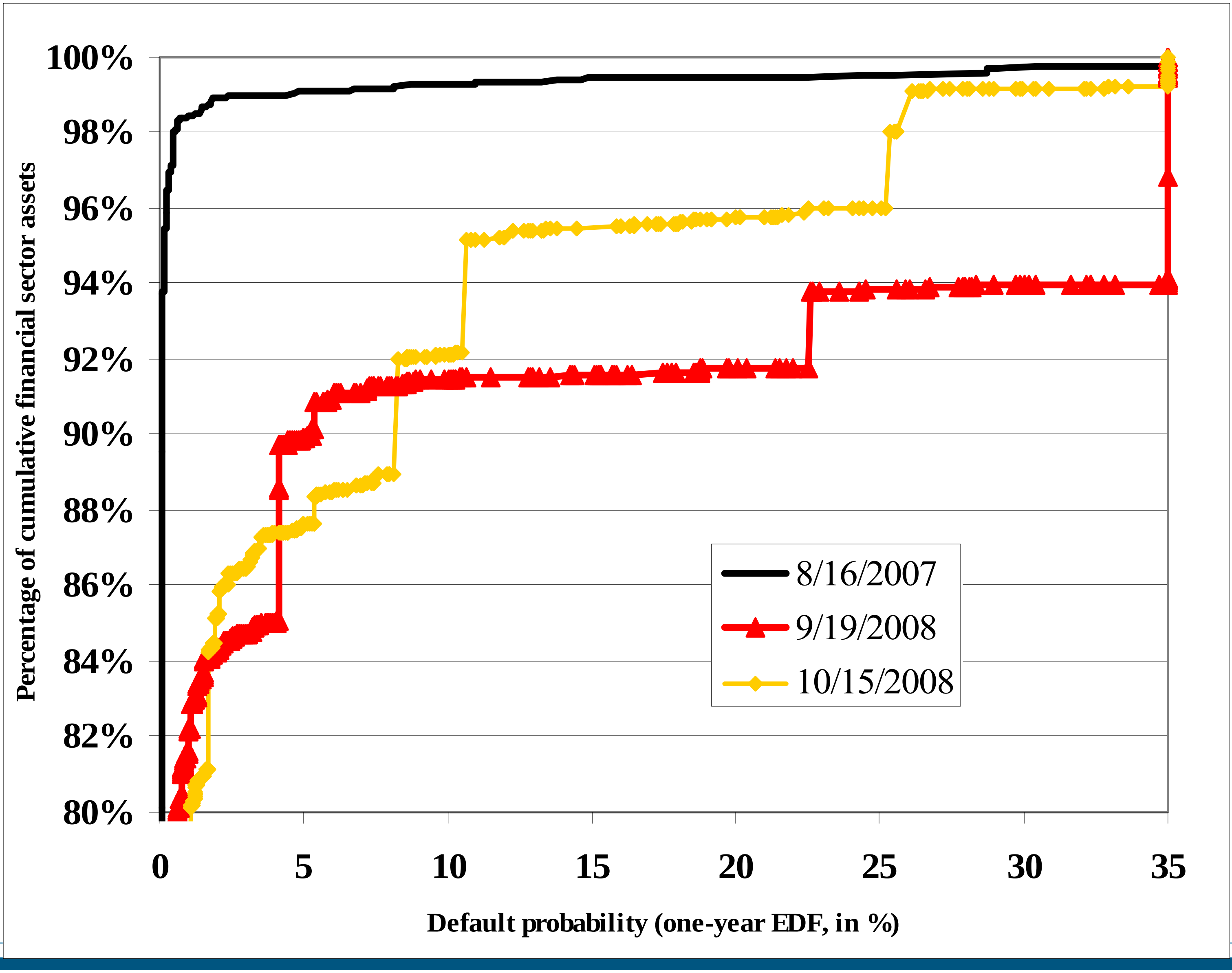
Changes in Bank CDS due to Leverage, Volatility and Impact of Increase in Market Price of Risk as of March 20, 2008
(Lower Risk Appetite, Higher Correlation)

	With Subprime Exposure/Loss	Without Subprime Loss
CDS January 2007	18	20
Increased Market Leverage	+52	+45
Change in Volatility	+41	+10
Market Price of Risk Increase (SR*ρ)	**+75**	**+70**
CDS March 2008	190 bps	145 bps

Subprime Crisis Impacts - Economic Capital Ratios Changes with Low and High Market Price of Risk



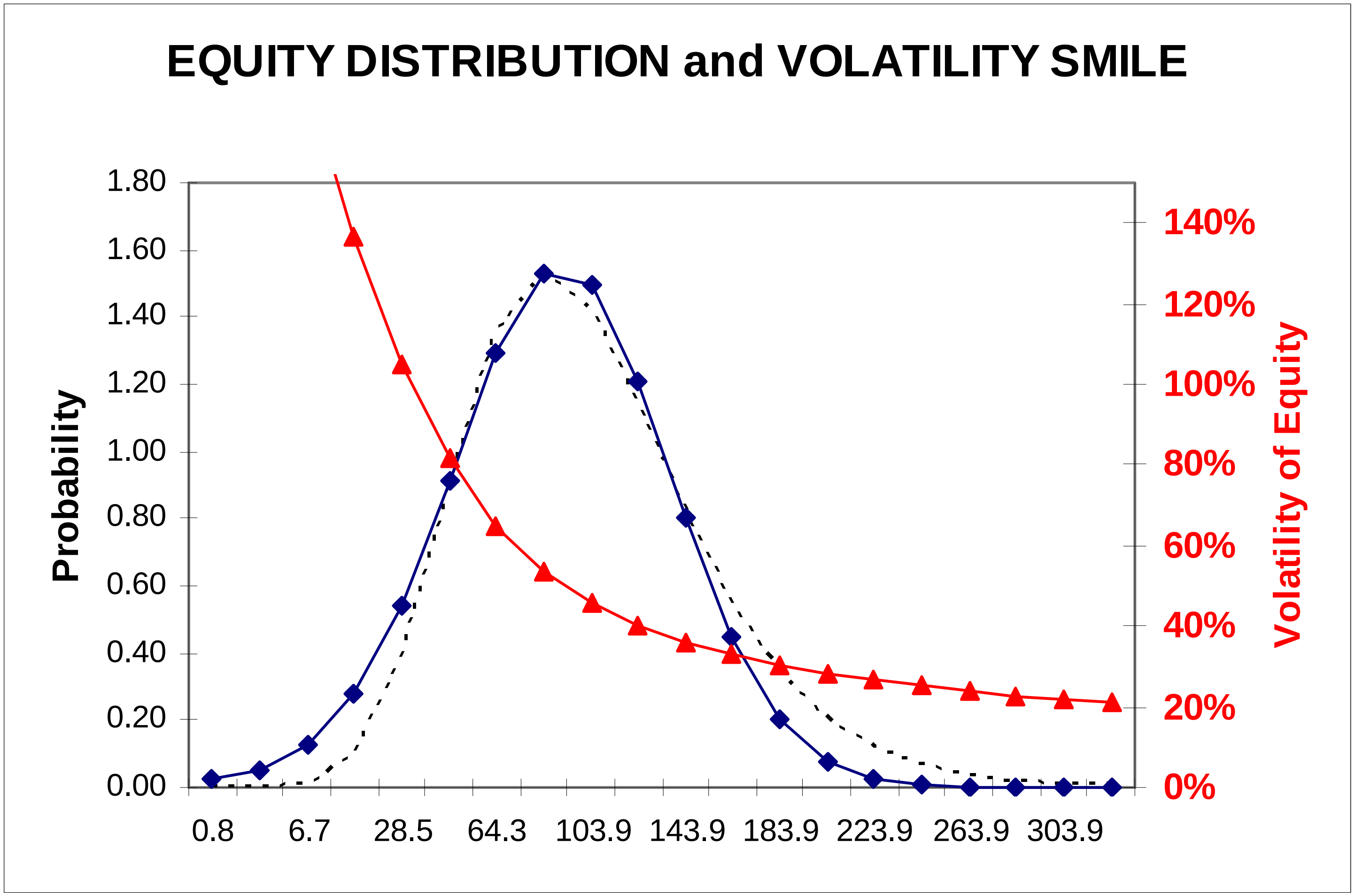
Cumulative Assets of US Financial Institution vs Expected Default Frequency (EDF) from MKMV (1-yr asset loss $84 bn 8/07, $ 700 bn 9/19/08, $ 521 bn 10/15/08)



Calibrating Higher Moments of the Asset Distribution in CCA/Structural Models to Calculate Credit Risk

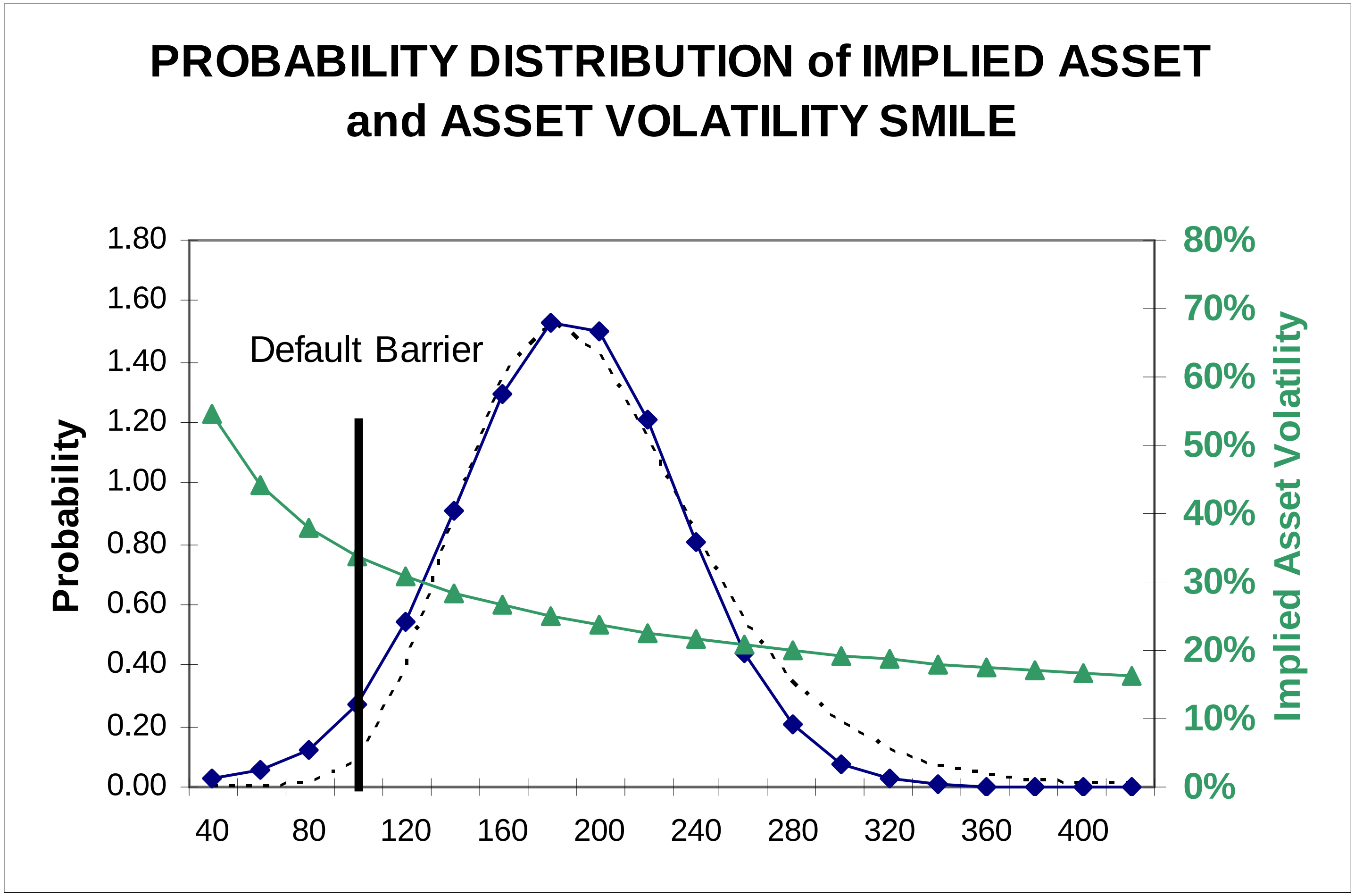
- Third moment---SKEW—is very important……Tail-Risk
- Need the relationship of equity and equity volatility; when equity declines its volatility goes up
- Extensions of Merton Model to account for fat-tails, stochastic volatility, jumps
  - Jump diffusion
  - Stochastic volatility
  - Direct estimation of higher moments of asset distribution
- Explicit equity options are a forward-looking view that can be used to calibrate higher moments of asset distribution and estimate credit risk
- Without equity options historical recent equity and equity volatility relationships can be used

Information from Volatility Smile from Equity Options Reflects "Fat-tail" and Left hand Skew



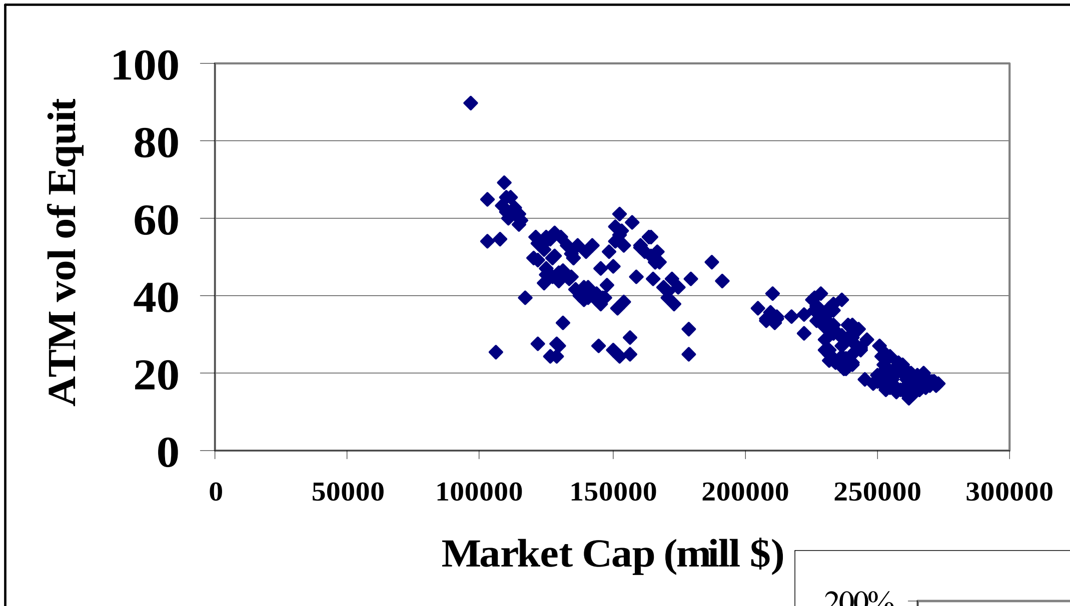
Smile from implied volatility of explicit equity options

Using the CCA Model to Get Implied Asset Distribution Results in "Fat-tail/Left hand Skew" and Asset Vol Smile

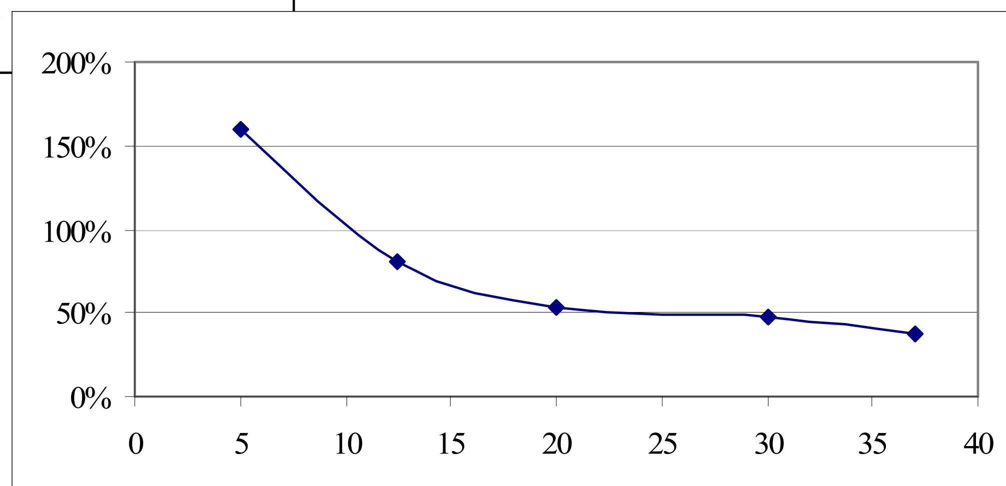


Volatility Smile and "Fat Tail" in Asset Distribution

Use Information from Relationship of Equity/Market Cap to Equity Volatility (Citigroup example)

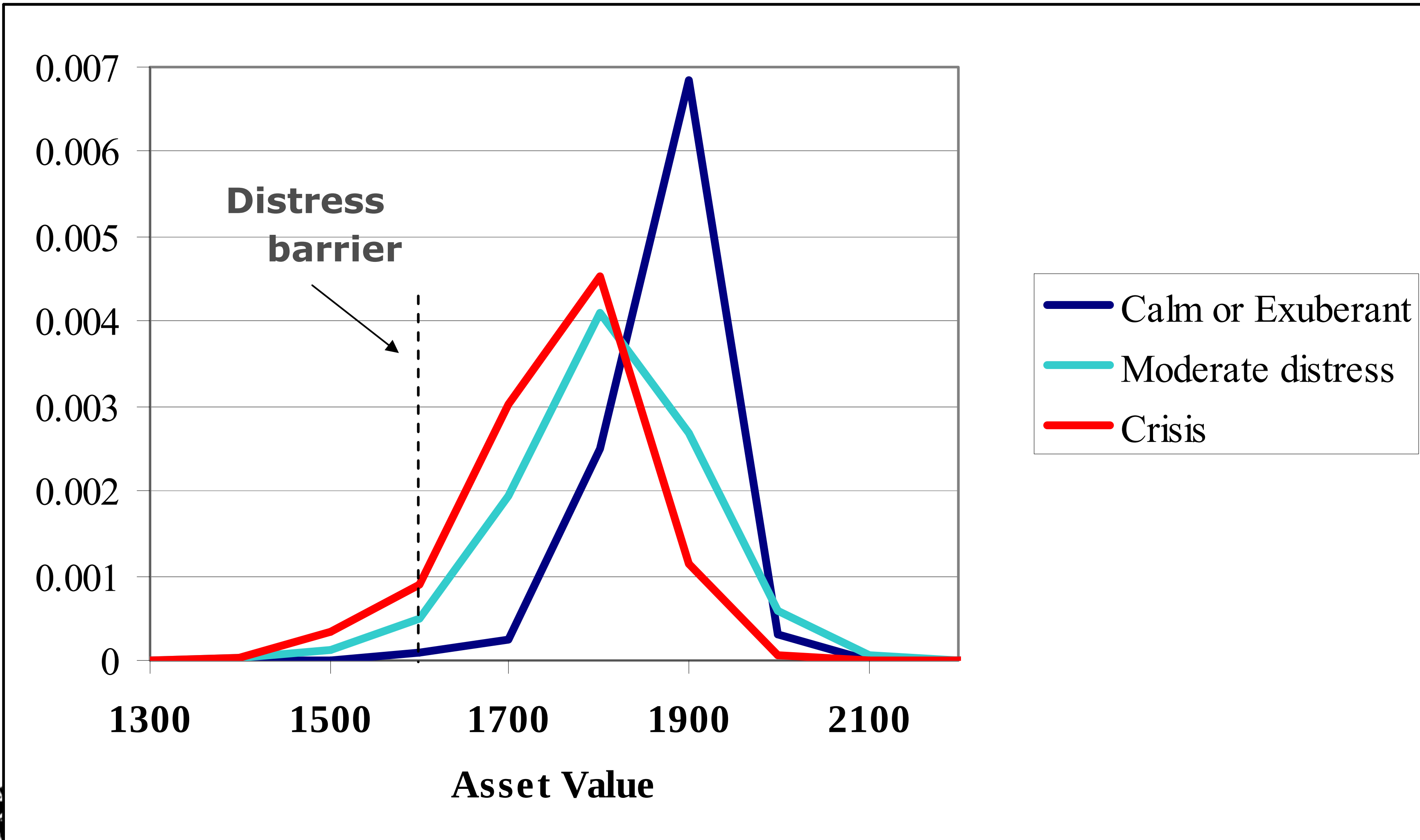


Lower Mkt Cap, higher vol (ATM options) over last year

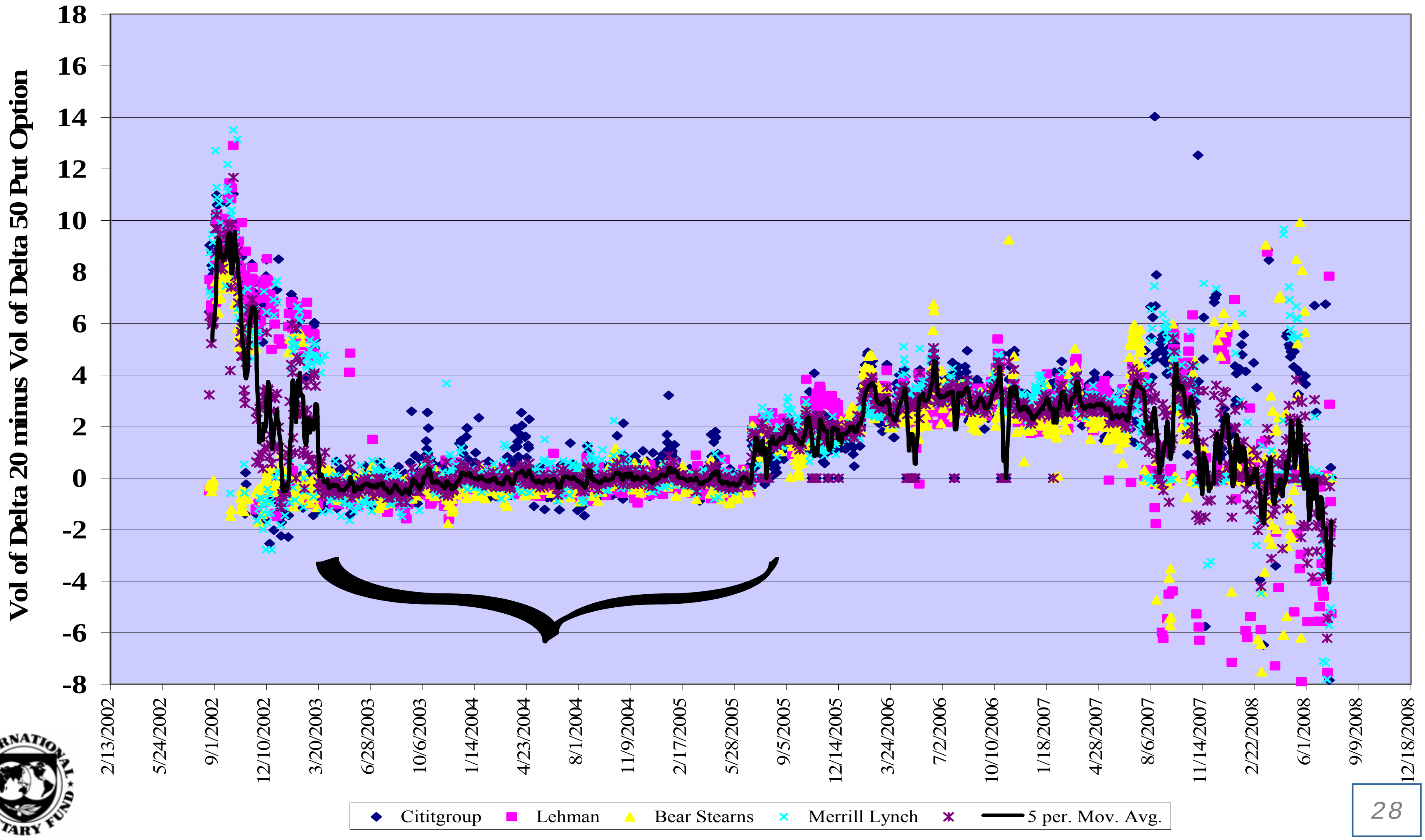


Smile from implied volatiltiy of explicit equity options

Citigroup: Change in Implied Asset Distribution going from Calm (12 bps) to Moderate Distress (124 bps) to Crisis (236 bps)



Extended Period of No or Negative Equity Put Skew for US Financial Institutions - January 2003 to October 2005



Interactions and Feedbacks between Financial Institutions in the Crisis

- **Interactions between financial institutions creates feedbacks and systemic risk**
- **Need to look at a system of CCA models of key institutions to analyze financial contagion**
- **Destabilization mechanisms key to understanding this crisis and other crises**

  (See *Macrofinancial Risk Analysis* Chapter 16)
- **Simple simulation models of a system of CCA models with "implicit knock-in fire sale/MTM options" illustrates possible cause of very fat tails**
- **Tail risk dependence measures between banks' equity and implied asset distributions**

INTERNATIONAL MONETARY FUND

Enhanced CCA/Structural Models Financial Institutions

- **Using Enhanced CCA/Structural models**
  - **Drivers of CDS Spreads - Moody's-KMV Expected Default Frequency (EDF) and EDF Implied CDS**
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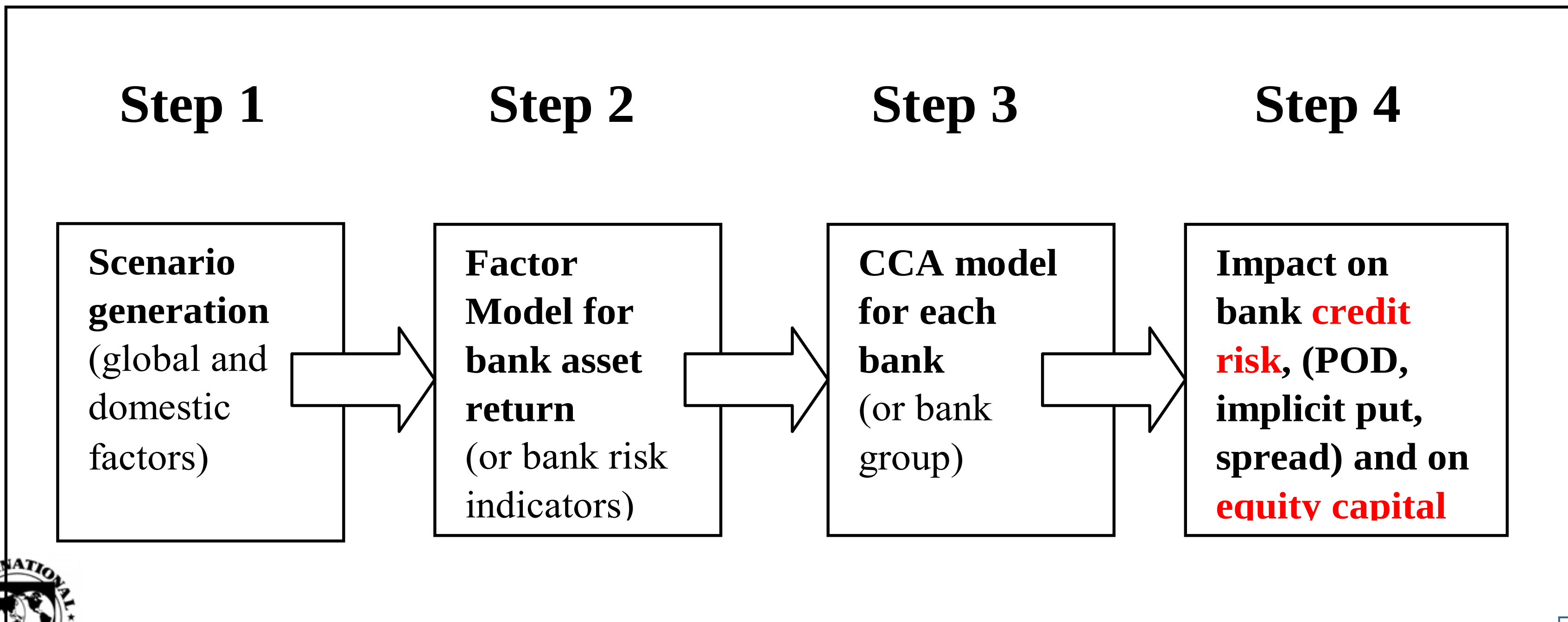
Bank-by-Bank CCA and Factor Models for Stress-Testing

Procedure:

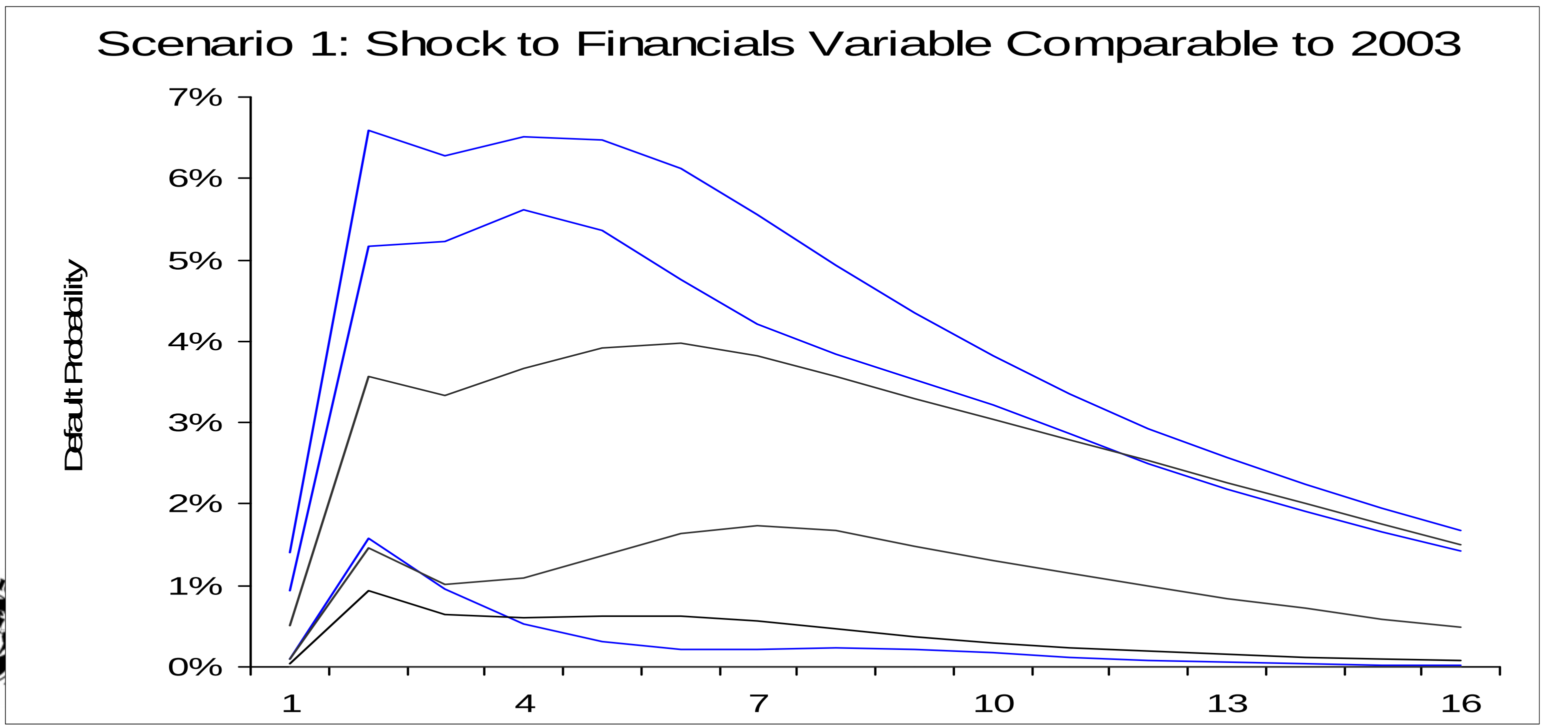
- Calibrate CCA model for each bank
- Estimate factor model for bank return
- Generate scenarios and carry out stress test to see impact on bank credit risk and on equity capital



EXAMPLE OF CHILE BANK FACTOR MODEL - Banks have Heterogeneous Response to Individual Factors; Stress testing can be with individual factors or with Four Principal Components

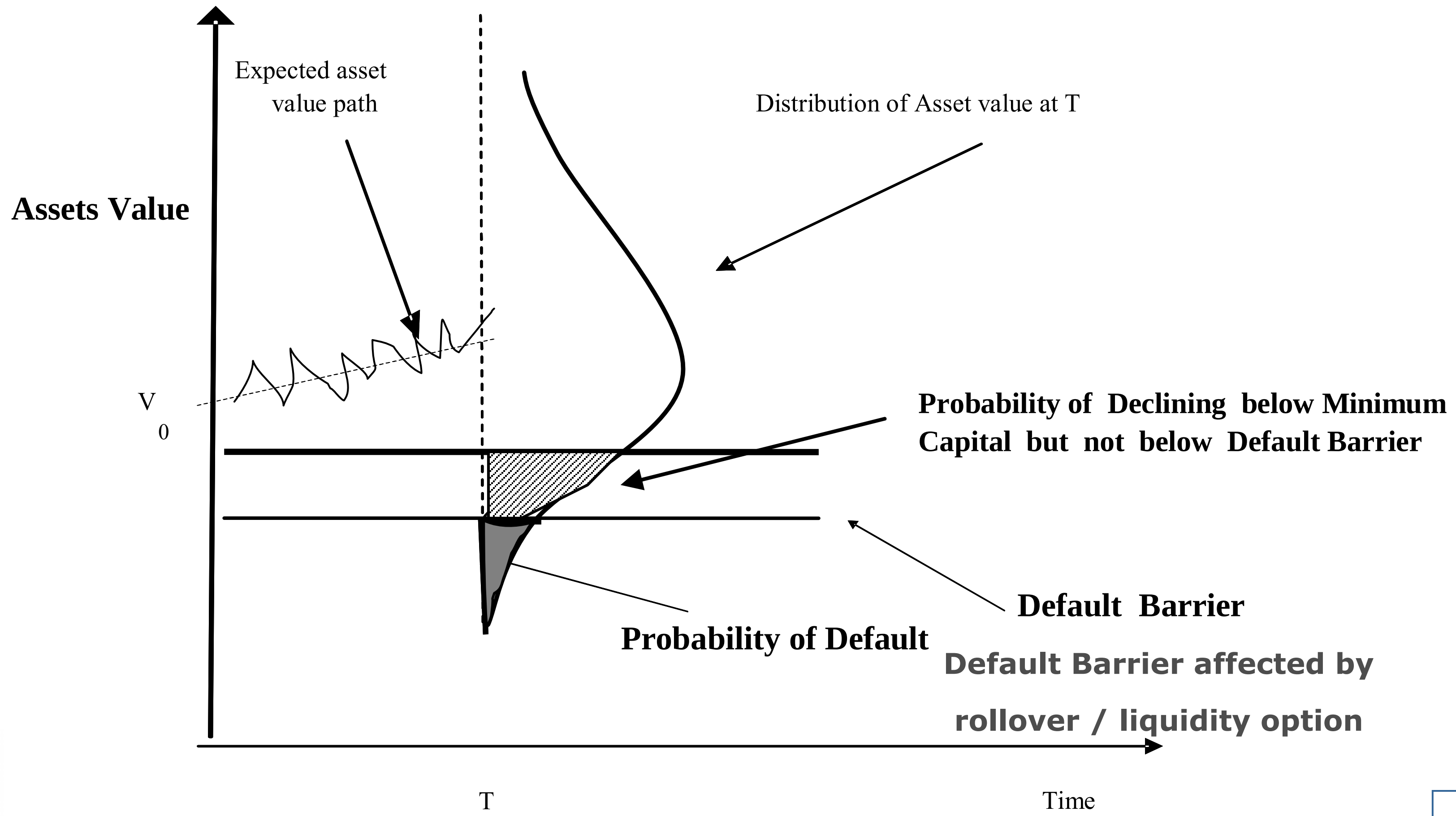
Factors associated with different components of asset returns

Factor 1	Factor 2		Factor 3	Factor 4	
VIX	U.S. Rates		Chile CPI	IMACEC	Chile Unemp.
S&P	Yld Curve	10-Yr (Chg)	Oil	Chile CPI	CLP / BRL
IPSA	1-Yr (Lvl)	1-Yr (Chg)	Copper	Copper	
CLP / USD			US CPI		



Minimum Capital Barrier / Implicit Put Option vs Default Put Option

Figure 2 Volatile Assets Relative to Debt Distress Barrier and "Minimum Capital Barrier"



CCA Equations for Financial Institutions when there are Implicit or Explicit Financial Guarantees

In the presence of financial guarantees government authorities provide contingent financial support equal to $\alpha_B P_B$, where α_B is the fraction of the put option P_B covered by the financial guarantor. The value of risky debt/deposits retained by the bank is $.(\bar{B}_B - (1-\alpha_B)P_B)$

$$
\begin{aligned}
A_B &= E_B + (\bar{B}_B - P_B) \\
&= E_B + (\bar{B}_B - (1-\alpha_B)P_B) - \alpha_B P_B
\end{aligned}
$$

Estimating Cost of Government Contingent Liabilities

- The implicit put option derived from equity prices is:

$$Put_{Equity} = Be^{-rT}N(-d_2) - AN(-d_1)$$

- The implicit put option from CDS, Put_{CDS} , can be approximated with:

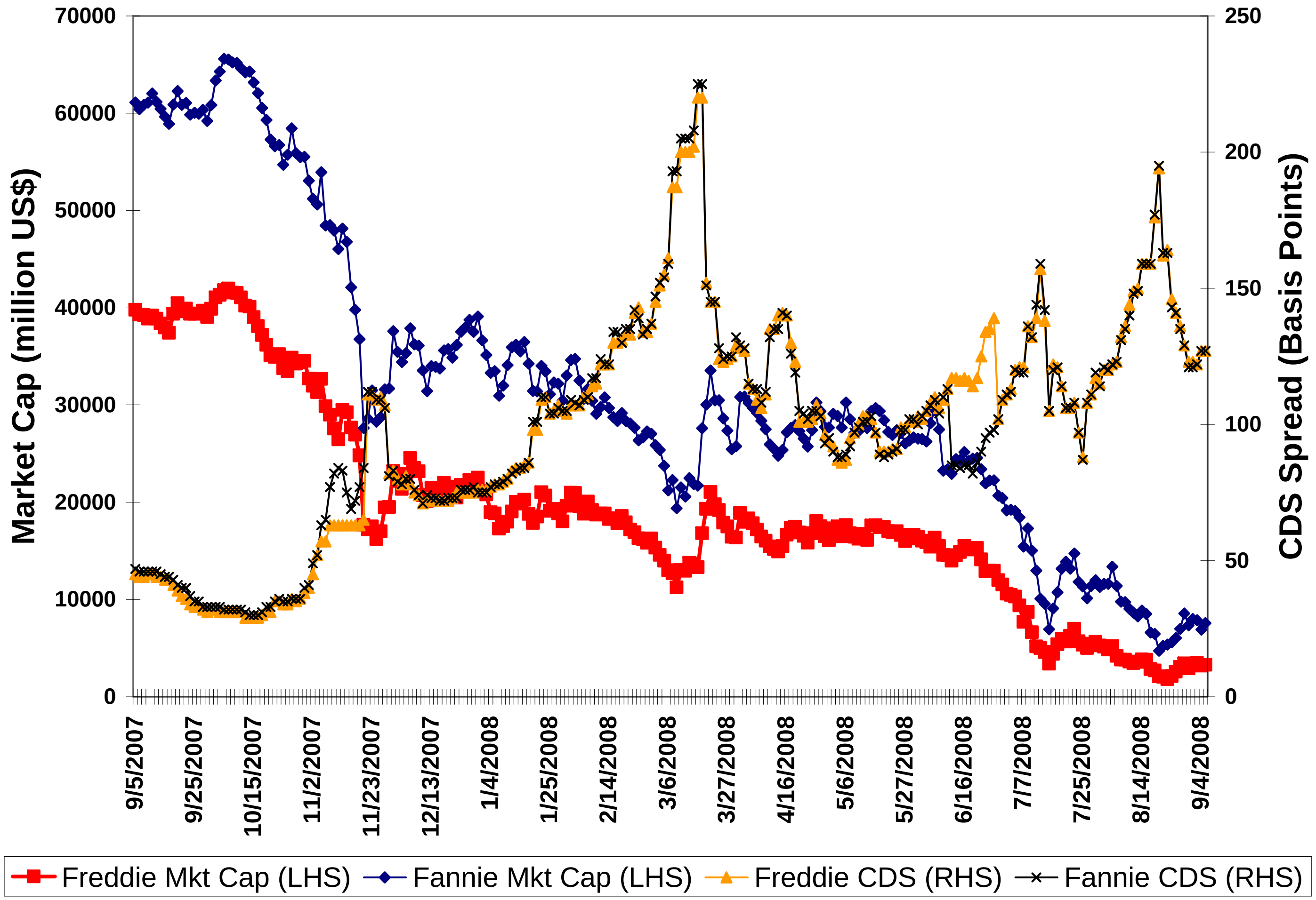
$$Put_{CDS} = \left(1 - \exp(-(CDS_{Basis\ Points}/10000)T\right)Be^{-rT}$$

- The fraction of the "total" implicit put option covered by the government's financial guarantee is defined as α ; which means that:

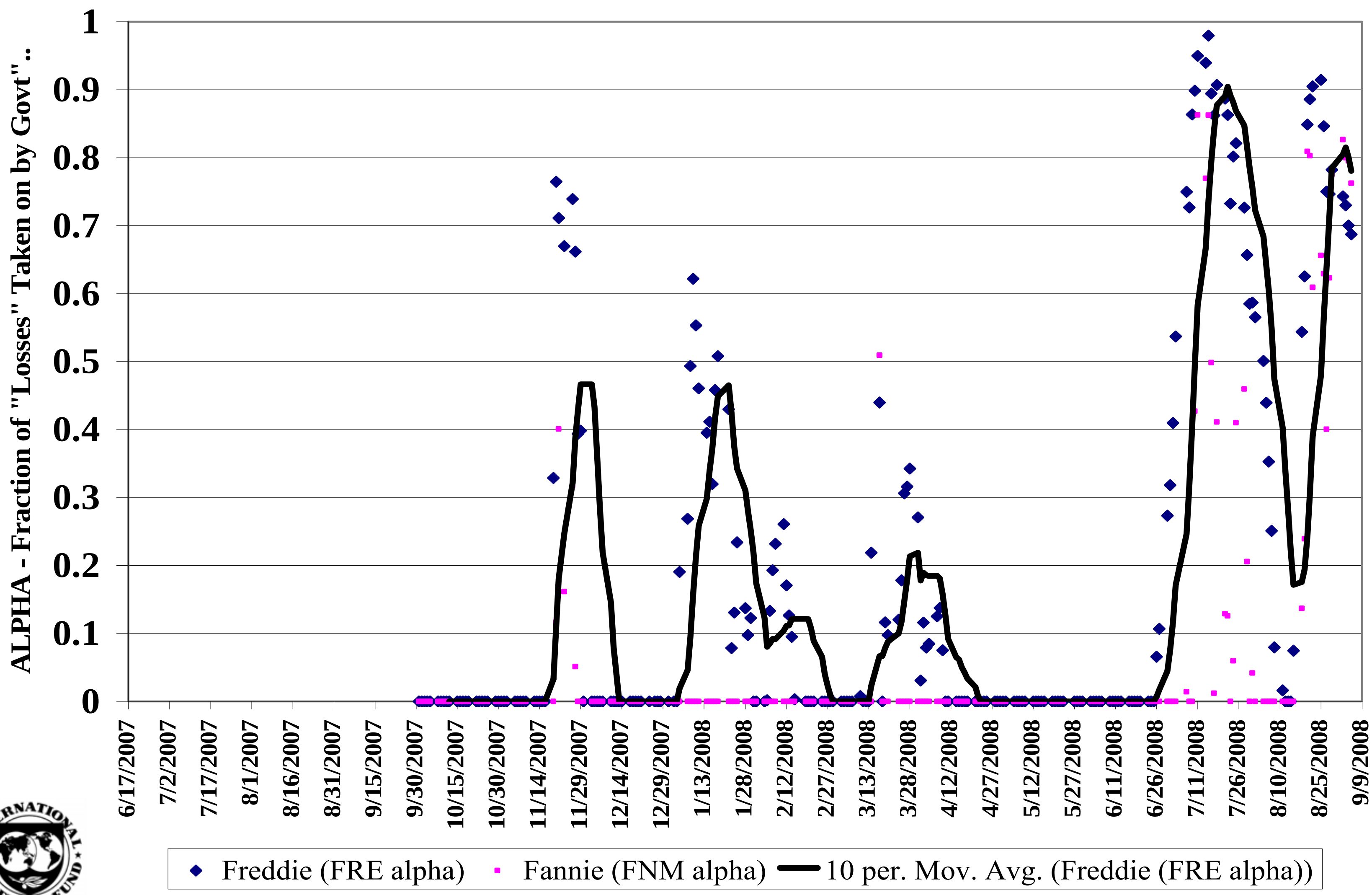
$$Put_{CDS} \cong (1-\alpha)Put_{Equity} \qquad \alpha = 1 - \frac{Put_{CDS}}{Put_{Equity}}$$

Using data from the CDS market to get Put_{CDS} , and from the equity market to get Put_{Equity} allows us to estimate α, the fraction of "total" loss covered by the financial guarantee and also estimate the size of the government's financial guarantee $\alpha\ Put_{Equity}$.

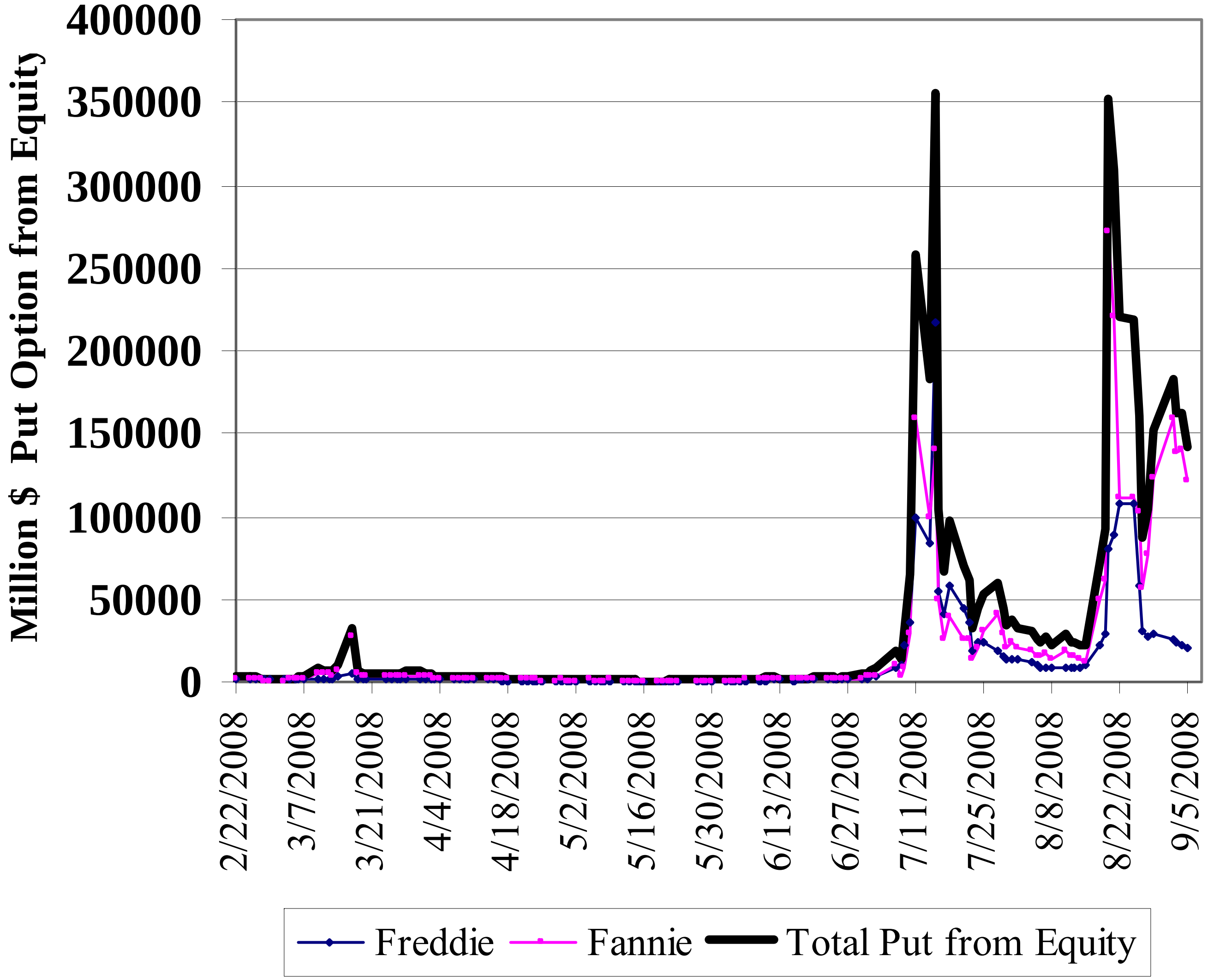
Estimating the Market's View of Contingent Liability Costs of Freddie and Fannie (the GSEs): Decline in Market Capitalization and Moderate CDS Spreads 9/07 to 9/08



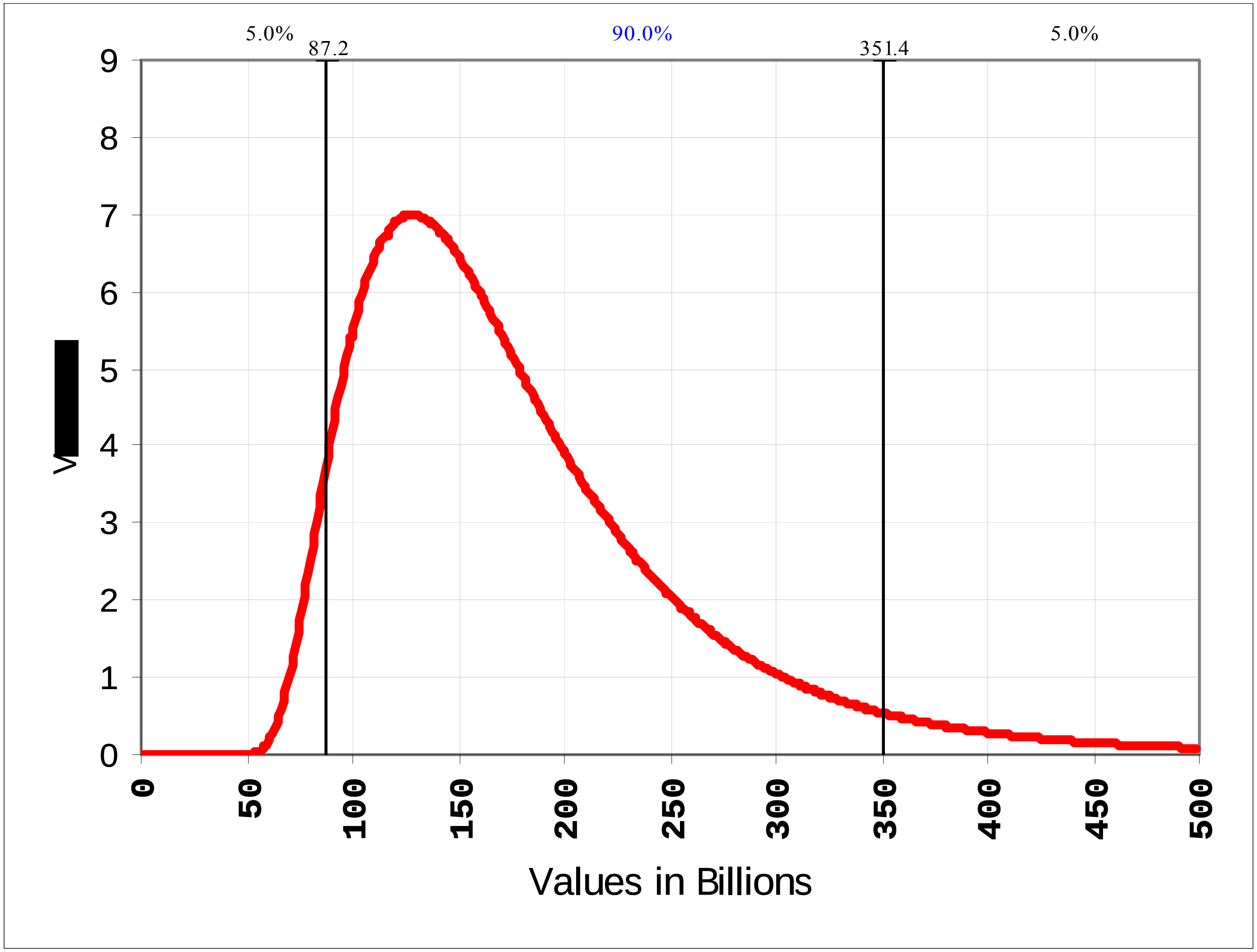
Estimated Value of ALPHA – Share of Implicit Put Option (Expected Losses) of GSEs taken on by the Government from Market Data



Evolution of the Implicit Put Option of the GSEs (from equity market)



Probability Distribution of Contingent Liability Costs to US Government of Taking Over Freddie and Fannie



Recap, Summary of Part II so far:

Enhanced CCA for Financial Institutions is Useful

- **MKMV gives EDF and shows CDS spread decomposition**
- **CCA calibrated with higher moments is useful for:**
  - **Analyzing regime changes (calm, average vs crisis regimes)**
  - **Equity option put skew better predicts expected losses (implicit put option), RNDP, and better predicts CDS (in absence of guarantees)**
- **CCA + Factor Model provides "CCA Early Warning Stress Testing System"**
- **Financial Guarantees Need to Be Accounted for; they affect CDS in a major way. Market equity-based CCA captures risk even in presence of guarantees. Will guarantees cause bank CDS spreads converge to sovereign spreads?**
- **Need to focus on minimum capital barrier (and implicit risk), as well as default risk**

CCA Framework Useful for Analysis of Impact of Financial Guarantees, Equity Injections on Financial Stability and Fiscal

- **CCA can be used to measure cost and benefits of:**
  - Ad hoc bailouts
  - Deposit insurance
  - Equity injections
  - Asset Purchases
- Target retained risk in systemically important institutions

……..**But financial guarantees/asset purchases/equity injections must be viewed in the context of the implications for credit growth, GDP and monetary policy targets**

New Interlinked Sector Policy Framework – Target Financial Stability, GDP and Inflation

GDP = *f* (lending growth/credit extension)

= *f* (CCA risk indicators for banks & leverage and non-bank financial structured credit)

Targets - (i) minimize retained risk in systemically important institutions;

(ii) GDP target

(iii) Inflation

Minimize Cost of Contingent Liabilities (financial guarantees, cont equity injections, and toxic asset purchase); Evaluate fiscal impact of contingent liabilities, and impact on monetary policy

Need Aggregate CCA-Based Indicators for Macro, Credit Growth and Monetary Policy Models.

Ways to Aggregate CCA Financial Stability Indicators

Weight distance-to-distress for each institution by the implied assets of each bank/financial institution to get a system risk indicator.

Weight of the volatility and/or skew from put options on equity of key financial institutions by the assets of the institution; or sum the implied CCA put option values

Tail risk dependence measure from equity options or implied assets in a portfolio of institutions

Calculate the joint distribution of default probabilities in a portfolio of financial institutions.

Real world EDF Aggregate Indicators: Weight EDF by bank assets; Use the median or 75% quartile EDF for the sub-sector or group, e.g. as calculated by MKMV.

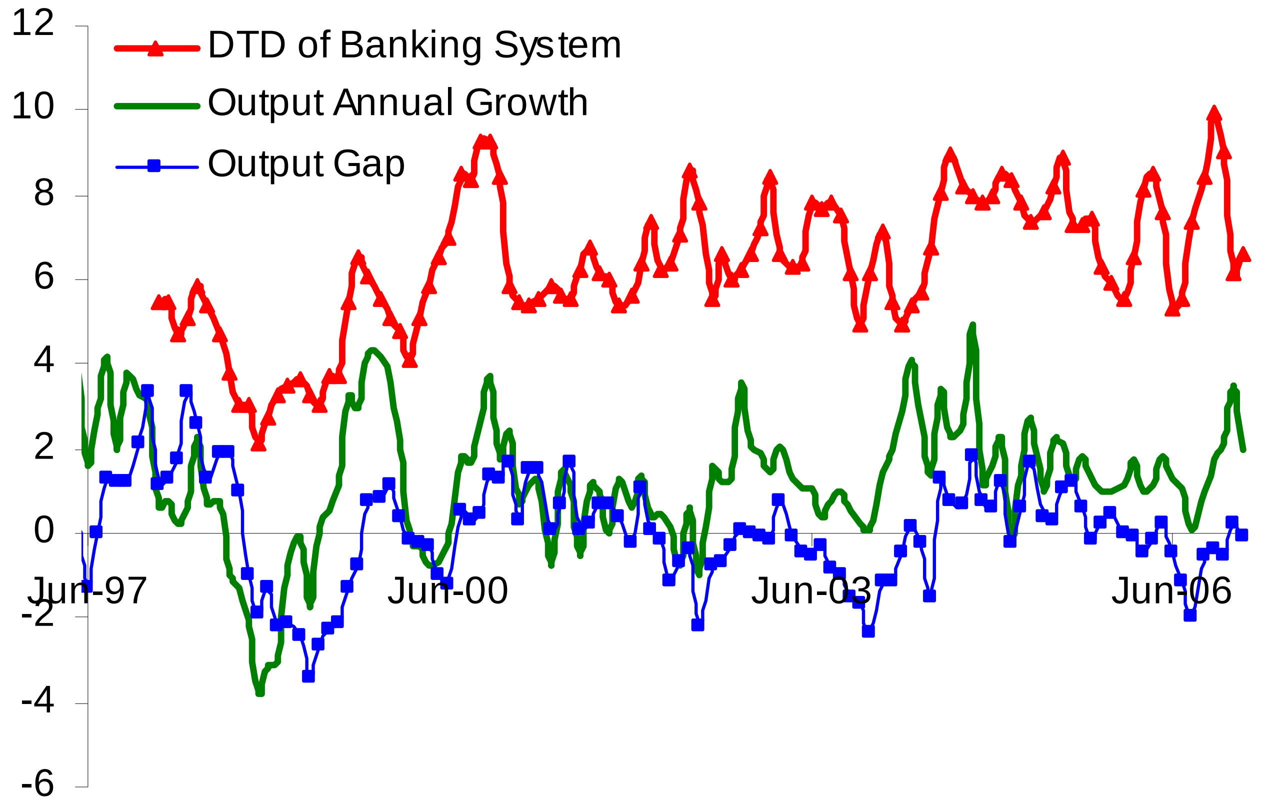
PART III Incorporating Financial Sector Risk into Monetary Policy Models
- *Jorge Restrepo, Leonardo Luna, and Gray*

GDP is affected by financial stability in the banking system via

- **Financial accelerator links;**
- **Financial distress in banks and bank's borrowers reduces lending as borrower's credit risk increases, which reduces investment and consumption affecting GDP.**
- **Explicit inclusion of CCA systemic credit risk/financial fragility indicator Should a financial fragility indicator be included in monetary policy models?**
  - **Yes, in the GDP Output Gap equation**

Chilean Banking System

Distance to Distress (*DTD*) for the Chilean Banking System, Output and Output Gap



DTD in GDP Growth for Chile

$$\Delta y_t = c + \alpha_1 r_{t-1} + \alpha_2 \Delta dtd_{t-1} + \alpha_3 \Delta e_{t-1} + \alpha_4 \Delta y_{t-1} + \varepsilon_t$$

Dependent Variable: DLOG(YS,0,3)
Sample (adjusted): 1998M05 2007M02
Included observations: 106 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	0.011	0.002	4.830	0.000
R(-1)	-0.001	0.000	-3.723	0.000
DLOG(TCR(-1),0,3)	**0.046**	**0.019**	**2.438**	**0.017**
DLOG(DTDS(-1),0,3)	0.012	0.003	3.551	0.001
DLOG(YS(-1),0,3)	0.463	0.074	6.283	0.000
R-squared	0.574	Mean dependent var		0.009
Adjusted R-squared	0.557	S.D. dependent var		0.013
S.E. of regression	0.008	Akaike info criterion		-6.677
Sum squared resid	0.007	Schwarz criterion		-6.552
Log likelihood	358.890	F-statistic		34.036
Durbin-Watson stat	1.912	Prob(F-statistic)		0.000

DTD in Output Gap for Chile

$$gap_t = c + \alpha_1 \Delta dtd_{t-1} + \alpha_2 \Delta e_{t-1} + \alpha_4 gap_{t-1} + \varepsilon_t$$

Dependent Variable: YGAP
Sample (adjusted): 1998M02 2007M02
Included observations: 109 after adjustments

Variable	Coefficient	Std. Error	t-Statistic	Prob.
C	-1.736	0.470	-3.691	0.000
DLOG(TCR(-3),0,3)	4.134	1.639	2.522	0.013
LOG(DTDS(-1))	**0.934**	**0.256**	**3.653**	**0.000**
YGAP(-1)	0.513	0.082	6.275	0.000
YGAP(-3)	0.225	0.072	3.113	0.002

R-squared	0.661	Mean dependent var	-0.035
Adjusted R-squared	0.648	S.D. dependent var	1.201
S.E. of regression	0.712	Akaike info criterion	2.204
Sum squared resid	52.766	Schwarz criterion	2.328
Log likelihood	-115.126	F-statistic	50.695
Durbin-Watson stat	1.842	Prob(F-statistic)	0.000

DTD has significant and positive impact on output gap

Monetary Policy + CCA Model

This paper uses a simple two-module framework:

1. Macro Monetary Policy Model.
2. CCA Financial System Module.

This macro model includes the financial stability/ credit risk indicator (banking system distance to distress) in the output gap equation and the exchange rate equations.

The model is calibrated with reasonable parameters (instead of estimated).

Monetary Policy Model (cont.)

GDP Gap:

$$ygap_t = \beta_1 ygap_{t-1} + \beta_2 ygap_{t-2} + \beta_3 ygap_{t-3} + \beta_4 (r_{t-1} - \bar{r}^{eq}_{t-1})$$
$$+ \beta_5 (rl_{t-2} - \bar{r}l^{eq}_{t-2}) + \beta_6 (q_{t-4} - q^{eq}_{t-4}) + \beta_7 \min(ldtd_t, 0) + \varepsilon^y_t$$

Uses the Traditional Taylor Rule:

$$r_{sd,t} = \rho r_{d,t-1}$$
$$+ (1-\rho)\theta(\gamma(\pi^e_{t,t+T} - \pi^T) + (1-\gamma) y_t) + \varepsilon_{4,t}$$

And Use Taylor Rule with Financial Stability Indicator:

$$r_{sd,t} = \rho r_{d,t-1} + (1-\rho)\theta(\gamma(\pi^e_{t,t+T} - \pi^T) + (1-\gamma) y_t *)$$
$$+ \beta_{10} dtd_t + \varepsilon_{4,t}$$

Monetary Policy Model (cont.)

Inflation:

$$\pi_t = \beta_5 \pi_{t-1} + \beta_6 y_t + \beta_7 \pi^e_{t,t+T} + \beta_8 \Delta q_{S,t} + \beta_9 s_{LCD} + \varepsilon_{2,t}$$

Real Exchange Rate:

$$q_t = \delta_1 q_{t-1} + \delta_2 q_{t+1} + (1 - \delta_1 - \delta_2) q^{eq} + (r - rf) + \delta_4 \min(ldtd_t) + \varepsilon^q_t$$

Yield Curve: long run interest rate (*rl*):

$$(rl_t - rl^{eq}) = \delta_1 (rl^e_{t+1} - rl^{eq}) + \delta_2 (rl_{t-1} - rl^{eq}) + (1 - \delta_1 - \delta_2)(r_t - rl^{eq}) + \varepsilon^{rl}_t$$

Feedback of GDP on Equity of Banks (Endogeneity)

DTD and GDP-gap affect each other.

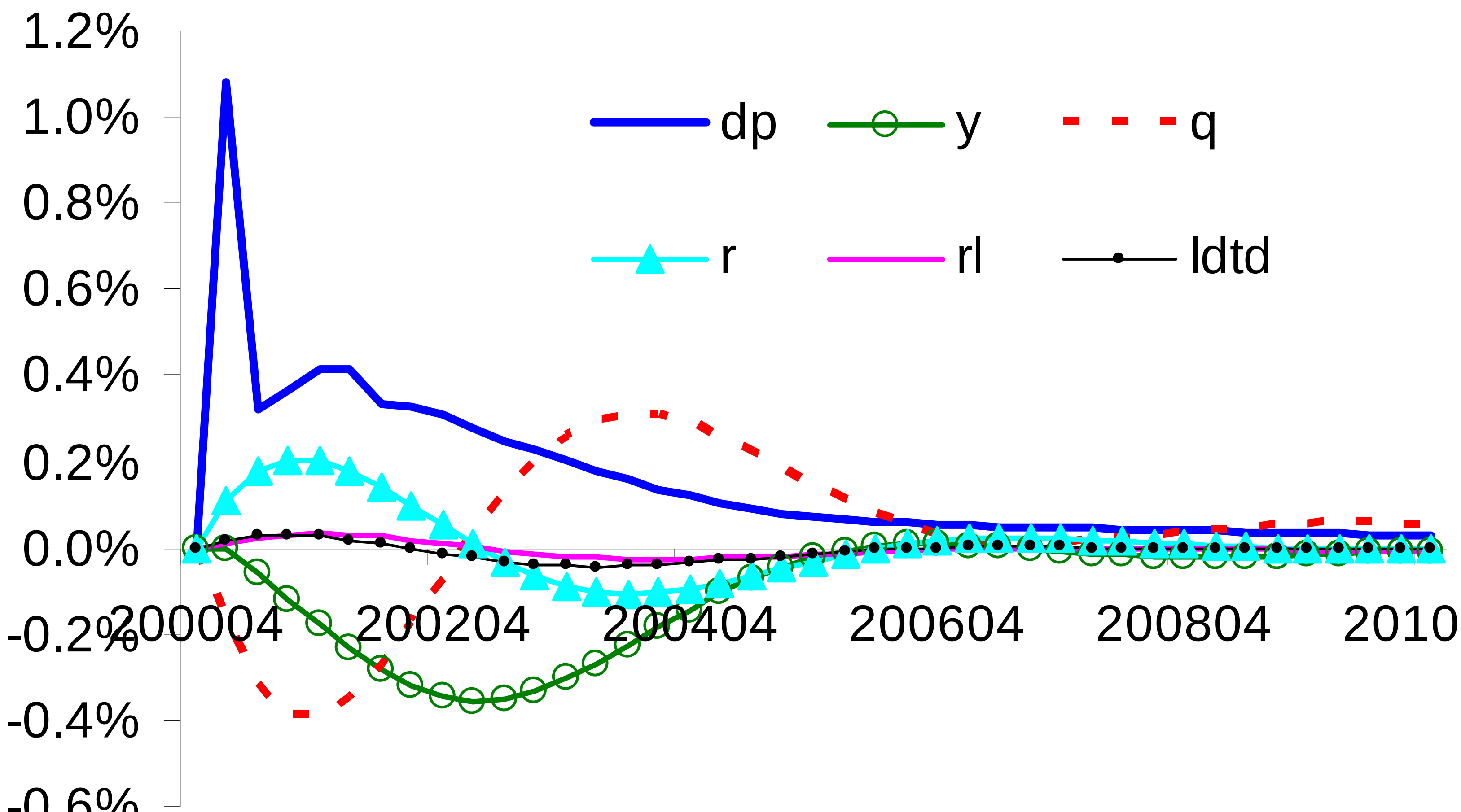
In order to include this into the model, we define one additional equation where the value of the equity of banks depends on the GDP-gap.

$$E_t = E_{t-1} + \beta \Delta y_t$$

This beta is a macro factor.

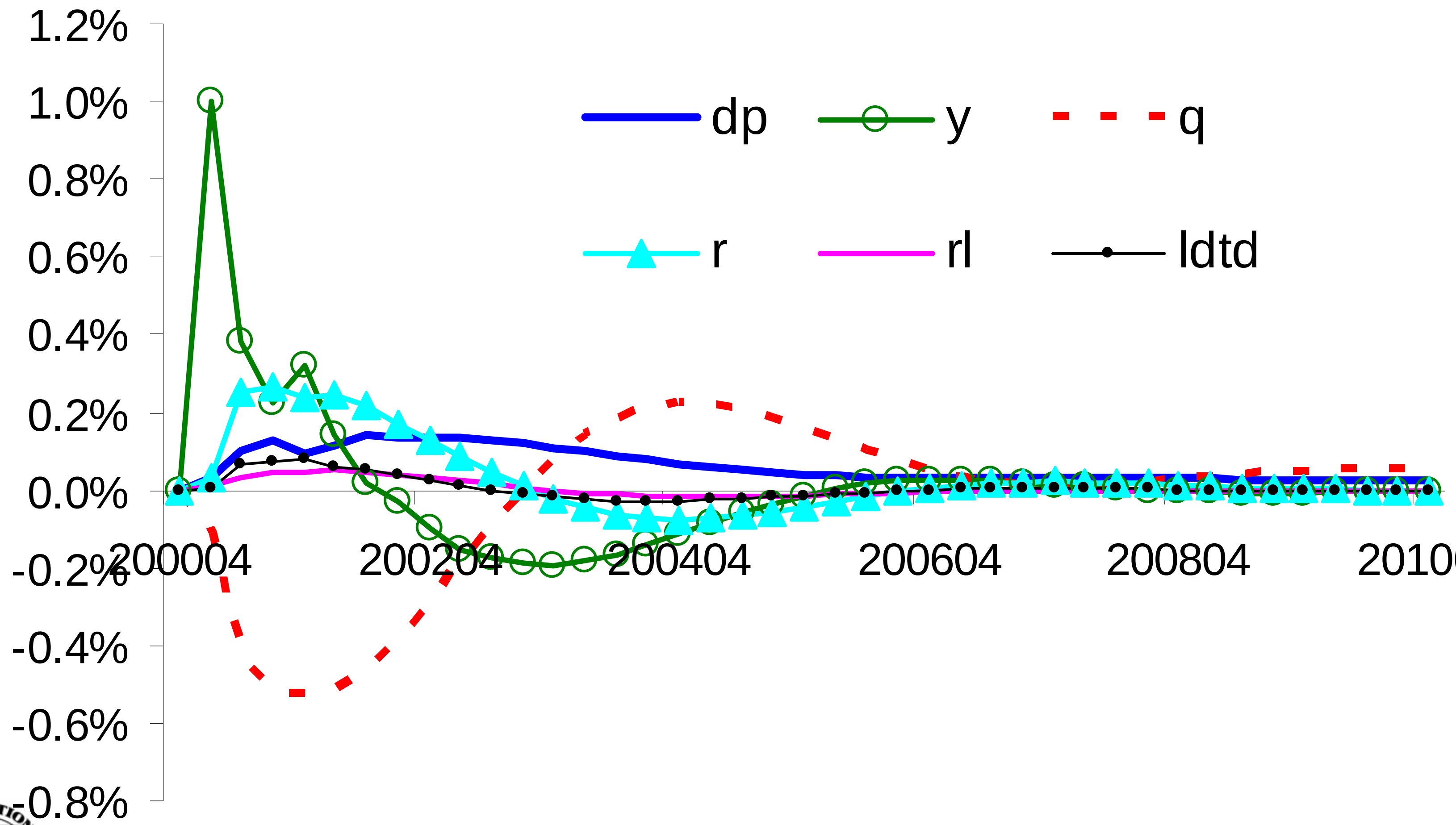
The model is run with and without this equation.

Impluse Responses
Shock to inflation (cost push +100bps)

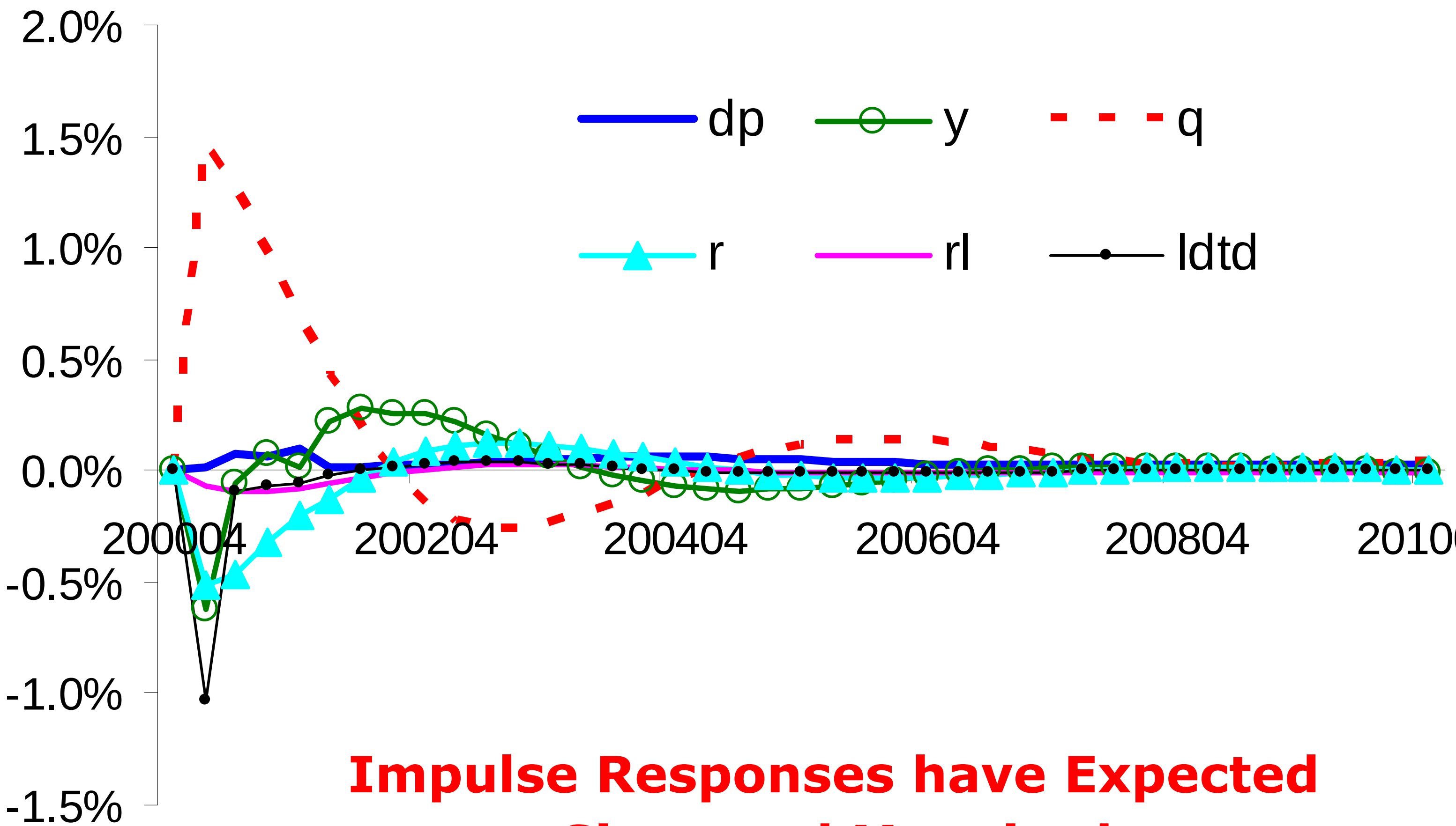


Note: basic model has classic Taylor rule parameters

Impluse Responses (cont.)
Shock to output gap (demand shock +100bps)



Impulse Responses (cont.)
Shock to distance to default (-100bps)



Impulse Responses have Expected Signs and Magnitudes

Efficiency Frontiers

Efficiency frontiers combine volatilities of inflation and GDP after the economy is repeatedly hit by shocks.

MPR that reacts to Financial Fragility (DTD) is compared with the baseline policy rule with inflation and GDP in it.

Each monetary rule is solved for different values of gamma: the relative reaction to inflation and GDP (output gap).

The policy choice is better when the frontier is closer to the origin.

Efficiency Frontiers (cont.)

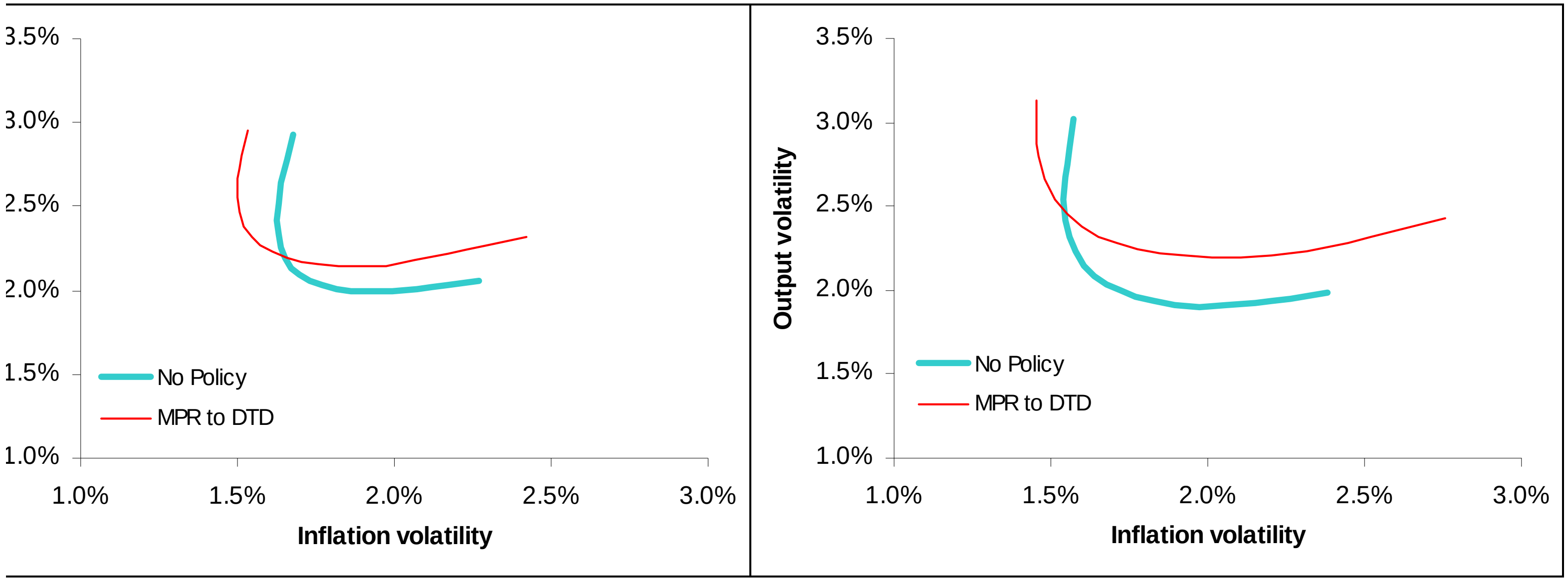
In what follows, some characteristics of the based model are changed:

1. **Lower sensitivity of bank equity to GDP (LE).**

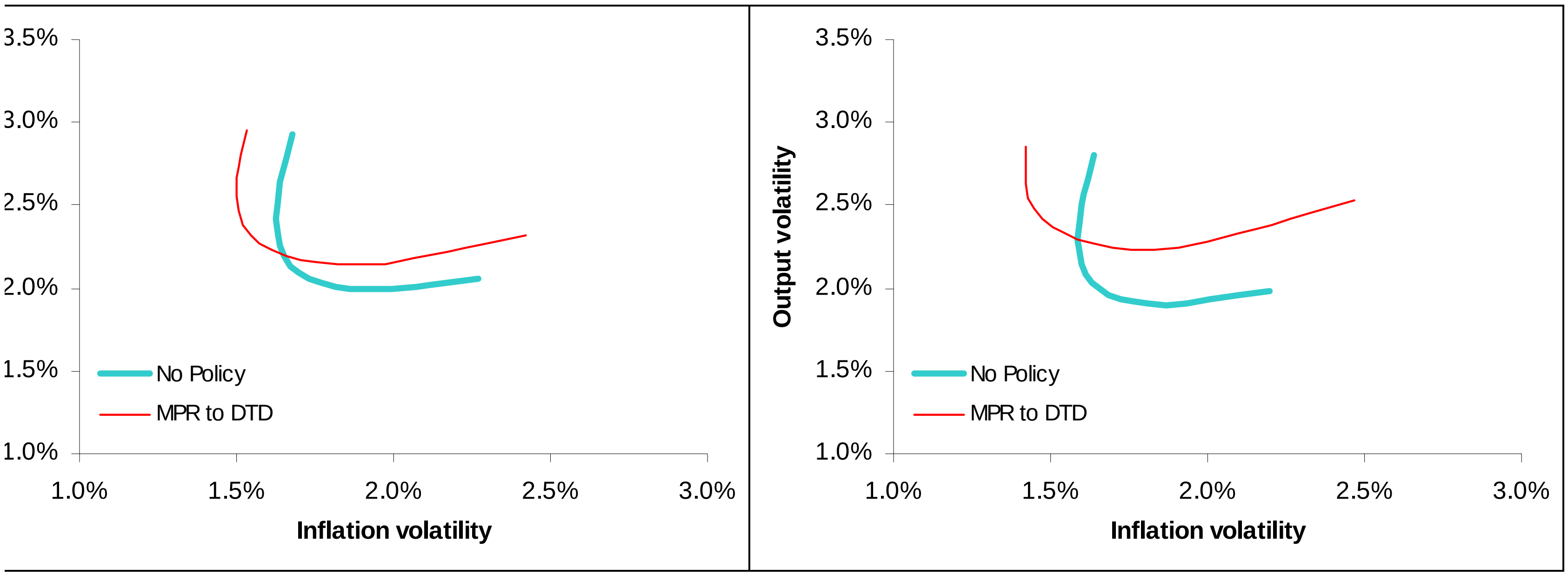
2. **LE plus lower pass-through of the nominal exchange rate to inflation.**

Smaller GDP effect on bank's equity (endogeneity)

- **If there is no feedback from GDP to bank equity and thus to *dtd*, the policy that excludes *dtd* is preferred: it leads to a frontier that is closer to the origin.**



- **If there is a higher sensitivity of bank equity to GDP, and higher sensitivity of inflation to ER pass-through, and higher sensitivity of ER to DTD - *then including DTD in the policy reaction function is preferred***



Results and Conclusions

A simple, but powerful model for monetary policy including financial sector risk.

It has the main variables analyzed by policymakers, but is small enough to understand it easily.

Empirical evidence supports the model.

Impulse Responses behave according to theory.

Robust efficient frontier, but there is a trade off in the results:

- A stronger reaction to DTD reduces inflation volatility but increases output volatility.
- It may be preferable to have interest rates react to DTD in certain circumstances.

Next Steps for Future Work

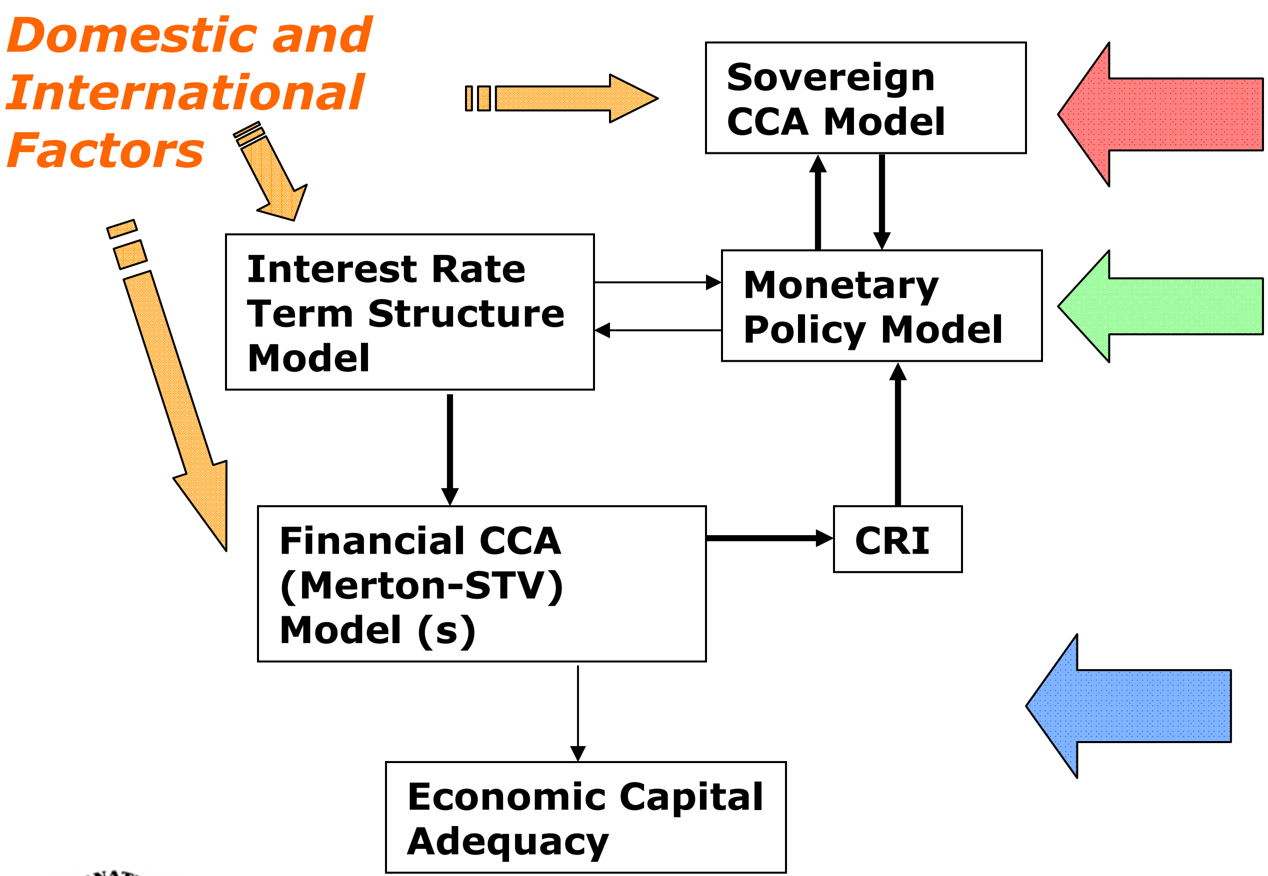
Combinations of financial scenarios (strong, normal, fragility) should be incorporated.

Changes in the dynamic of the macro model should be tested (maybe move to DSGE).

Test different types of Financial Stability indicators.

Look for empirical evidence in other countries and comparison of the model with other economies.

Unified Macrofinance Framework
(Targets: GDP, Inflation, Financial System Credit Risk, Sovereign Credit Risk)



Policies:

- Fiscal Policy
- Debt Management
- Reserves / SWF

- Policy Rate

- Economic Capital Adequacy
- Bank and Financial Sector Regulations

Thank you, More information see:

Papers by D. Gray, Robert C. Merton, Zvi Bodie:

- ***NBER 12637 (2006)***
- ***NBER 13607 (2007)***
- ***Sovereign Credit Risk, JOIM v. 5, no. 4, Dec 2007***
- ***HBS WP 09/015 August 2008***
- ***CCA and the Subprime Crisis (Gray, Merton, Bodie) found at:***

www.greta.it/credit/credit2008/Tuesday/06_Bodie_Gray_Merton.pdf

IMF Working Papers: ***WP 05/155, 04/121, 07/233, Indonesia SIP (2006), Gray and Walsh (WP 08/89), Gray, Lim, Loukoianova, Malone (WP/08), IMF Staff Papers Gapen et. al v 55 #1 2008; Framework for Integrating Macroeconomics and Financial Sector Analysis*** **by Gray, Karam, Malone, N'Diaye (forthcoming)**

Macrofinancial Risk Analysis***, Gray and Malone (Wiley Finance book Foreword by Robert Merton)***

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Merton Model CCA Risk Indicators and Values

Value of Risky Debt, D (B=distress barrier, P=implicit put option)

$$D = Be^{-rt} - P = Be^{-rt} - (Be^{-rt} N(-d_2) - A_0 N(-d_1))$$

D-to-D= $d_2 = \dfrac{\ln\left(\dfrac{A_0}{B}\right) + \left(r_f - \dfrac{\sigma_A^2}{2}\right)t}{\sigma_A \sqrt{t}}$ $\qquad d_1 = d_2 + \sigma_A \sqrt{t}$

Default Probability

Risk Neutral DP $N(-d_2)$

Estimated Actual DP $N(-d_2^*) = N(-d_2 - \lambda\sqrt{t})$

$$d_2^* - d_2 = \frac{\mu_A - r_f}{\sigma_A}\sqrt{t} = \lambda\sqrt{t} = \rho_{Asset,Mkt} SharpeRatio_{Mkt}\sqrt{t}$$

Credit Spreads

$$s_{SrDebt} = -\frac{1}{t}\ln\left(1 - \frac{P_{BSr}}{B_{Sr}e^{-rt}}\right)$$

Market Price of Risk in CCA models

To get the Risk-neutral Default Probability one must use the EDF and the Market Price of Risk

MKMV uses CAPM, the excess return of a security is equal to the beta of the security times the market risk premium.

$$\mu - r = \beta(\mu_M - r)$$

Beta is equal to the correlation of the asset with the market times the volatility of the asset divided by the volatility of the market.

$$\beta = \frac{\operatorname{cov}(r_V, r_M)}{\operatorname{var}(r_M)} = \rho_{A,M} \frac{\sigma}{\sigma_M}$$

$$\mu - r = \rho_{A,M} \sigma \frac{(\mu_M - r)}{\sigma_M} = \rho_{A,M} \sigma SR$$

Here SR is the Sharpe Ratio for the market.

So, the market price of risk is:

$$\frac{\mu - r}{\sigma} = \rho_{A,M} SR$$

$$EDF_{Risk-Neutral} = N\left[N^{-1}(EDF) + \rho_{A,Mkt} SR\sqrt{T} \right]$$

	House-hold Real Estate Mortgage BS	RMBS CDOs	Financial LCBGs	Financial Primary Dealers	GSEs	Govt. And Federal Reserve
Asset	$A_{H,RE}$	$A_{RMBS,CDOs}$	A_B	A_{PD}	A_{GSE}	A_{Gov} $-\alpha_B P_B$ $-\alpha_P P_{PD}$ $-\alpha_G P_{GSE}$ $-Cont\ E_{Pr}$
Equity & Sub. Claims	$-E_H$	$-E_{RMBS,CDOs}$ $-Mez_{RMBS,CDOs}$	$-E_B$ $-E_{Pr}$	$-E_{PD}$ $-E_{Pr}$	$-E_{GSE}$ $-E_{Pr}$	
Barrier	$-\bar{B}_{H,RE}$	$-Sr_{RMBS,CDOs}$	$-\bar{B}_B$	$-\bar{B}_{PD}$	$-\bar{B}_{GSE}$	$-\bar{B}_G$
Expected Loss (Put)	$+P_{H,RE}$		$+(1-\alpha_B)P_B$ $+\alpha_B P_B$	$+(1-\alpha_P)P_{PD}$ $+\alpha_P P_{PD}$	$+(1-\alpha_G)P_{GSE}$ $+\alpha_G P_{GSE}$	$+P_G$
Sum	0	0	0	0	0	

Non-linear Risk Transmission

Risk Transfer to Sovereign Balance Sheet

- **Contingent Liabilities Raise Fiscal Costs**
- **Reduces Sovereign Assets, can increase Sovereign Spreads**
- **Sovereign CCA Model:**

A_{Sov} = Reserves + PV (primary fiscal surplus) – Contingent Liabilities

Sovereign Spreads = f (A_{Sov} , Vol A_{Sov} , $Debt_{Sov}$)

See JOIM paper December 2007, and book chapters 7, 8 and 13; Sovereign Capital Structure Arbitrage Chapter 21