PIMS Summer School on Systemic Risk

Introduction

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UBC Vancouver
July 21-23, 2014

Overview

- Too Big To Fail – I: Making (near) failure an option

- Too Big To Fail – II: Making failure less likely

- Too Interconnected to Fail?

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  - Analysis of ***contingent capital and bail-in debt*** to prevent disorderly bankruptcy or government intervention
  - Key issues are the incentives they create and the choice of trigger

- Too Big To Fail – II: Making failure less likely

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  - Design of ***risk weights***: Bank capital requirements have been based on risk-weighted assets since the 1980s
  - How should these risk weights be designed?

- Too Interconnected to Fail?

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- Too Interconnected to Fail?
  - Using network analysis to understand vulnerabilities in the financial system
  - What types of interconnections matter?
  - What can we say without detailed knowledge of the network topology?

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CoCos, Tail Risk, and Debt-Induced Collapse

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Joint work with Nan Chen, Behzad Nouri, and Markus Pelger

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Overview

- Contingent convertibles (CoCos) are debt that converts to equity when a bank gets in trouble
  - A built-in mechanism to increase capital when it is most needed and most difficult to raise
  - With a credible mechanism in place in advance, a government bail-out becomes less likely

- Will it work?

- What are the incentive effects of CoCos (and bail-in debt), and what drives these effects?

- How should the trigger for conversion be designed?

CoCo Conversion – Illustration

Assets	Liabilities
100	Debt = 90
	Equity = 10

Asset value drops 15%

Assets	Liabilities
85	Debt = 85
	Equity = 0

Firm is bankrupt and/or government steps in to compensate debt holders

CoCo Conversion – Illustration

Assets	Liabilities
100	Debt = 90
	Equity = 10

Asset value drops 15%

Assets	Liabilities
85	Debt = 85
	Equity = 0

Firm is bankrupt and/or government steps in to compensate debt holders

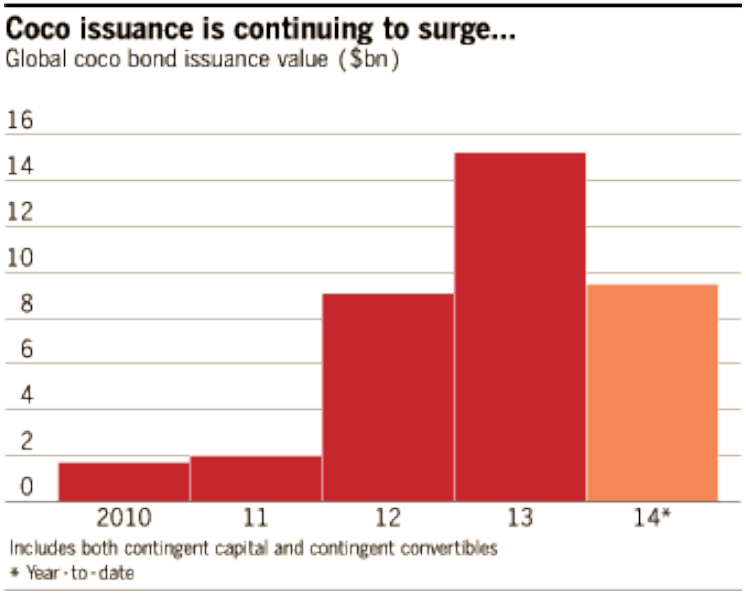
Assets	Liabilities
100	Debt = 60
	CoCo = 30
	Equity = 10

Asset value drops 15%

Assets	Liabilities
85	Debt = 60
	Equity = 25

Firm survives. Original shareholders lose everything, CoCo investors become shareholders

2014 On Track To See Record Issuance



2013 issuances

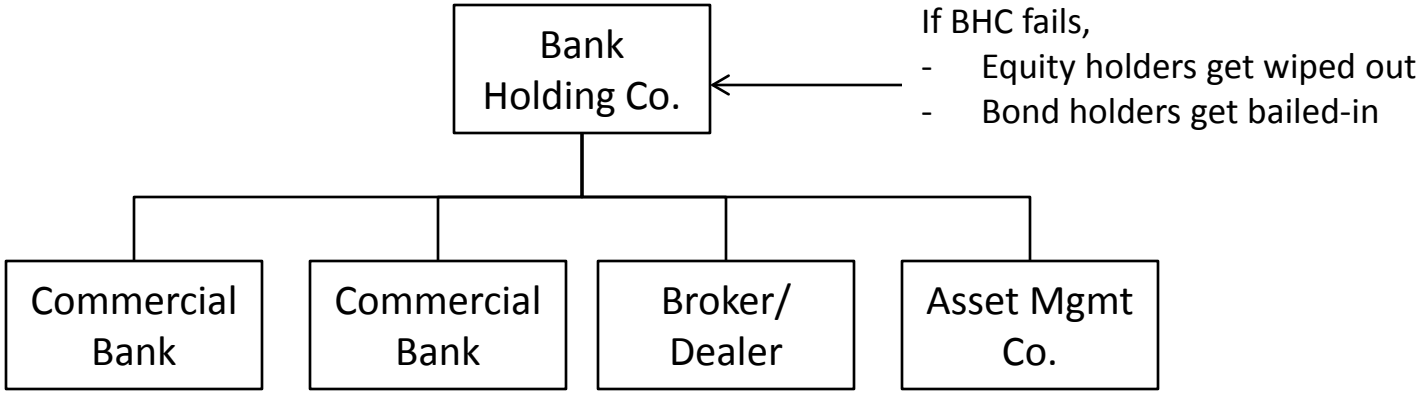
Issuer	Deal value ($m)	Date	Deal nationality
Credit Suisse	2,500	Aug 1	Switzerland
UBS	1,500	May 15	Switzerland
Bank of Ireland	1,311	Jan 9	Ireland
Barclays Bank	1,000	Apr 3	UK
KBC Bank	1,000	Jan 18	Belgium
Swiss Re	750	Mar 5	Switzerland
Credit Suisse	271	Aug 21	Switzerland
Valiant Bank	159	Mar 20	Switzerland

Source: Financial Times

2014 issuers include Deutsche Bank, Mizuho, Sumitomo Mitsui, Barclays, BBVA, UBS

Some of these take the form of write-down debt with no conversion

The Bail-In Model



- A large BHC has thousands of subsidiaries, many with their own liabilities
- TBTF reflects concern about disruption of services
- Single-point-of-entry solution
    - Convert BHC bond holders to equity holders in a new company
    - Units continue to operate and/or are sold off
    - BHC submits "living will" in advance for how it should be broken up
- For our purposes, this is like a CoCo in which equity holders are wiped out and conversion trigger is point of failure

Questions About CoCos and Incentives

- Will banks (and investors) behave differently after they issue CoCos, particularly near the conversion point?

- How does issuance of CoCos affect the incentives for shareholders to
  - Invest in the bank or declare bankruptcy
  - Take on greater or lesser risk in choosing the bank's assets

- How do debt maturity, tax treatment, bankruptcy costs, and tail risk influence the answers to these questions?

Related Research (Partial List)

- Flannery (2005,2009):
  - Proposed reverse convertible debentures, market trigger
- McDonald (2010), Squam Lake Working Group (2010)
  - Dual trigger: bank-specific and systemic
- Pennacchi (2010), Pennacchi, Vermaelen, Wolf (2010)
  - Jump-diffusion simulation model for valuation, incentives
- Albul, Jaffee, and Tchistyi (2010)
  - Diffusion model, infinite-maturity debt
- Sundaresan and Wang (2010)
  - Potential pitfalls of market triggers
- De Spiegeleer and Schoutens (2011)
  - Derivatives approach to valuation

What We Do

- Our model combines
  - Endogenous default by shareholders
  - Debt roll-over at various maturities and levels of seniority
  - Jumps and diffusion in cash flows and asset values

- Through these features, CoCos can create incentives for shareholders to
  - Reduce default risk (through capital structure and asset riskiness)
  - Invest in the firm to stave off conversion
  - Potentially take on additional tail risk

- These positive features rely on avoiding *debt-induced collapse*

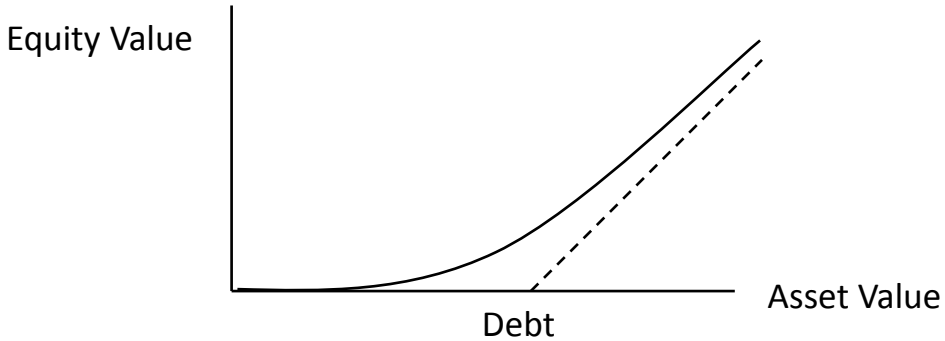
Outline

- Capital structure valuation and jump-diffusion model
- Debt-induced collapse
- Comparative statics and examples to address the incentive questions
- Calibration of the model to the largest US bank holding companies through the crisis

Capital Structure Valuation and the Jump-Diffusion Model

Background on Capital Structure Models

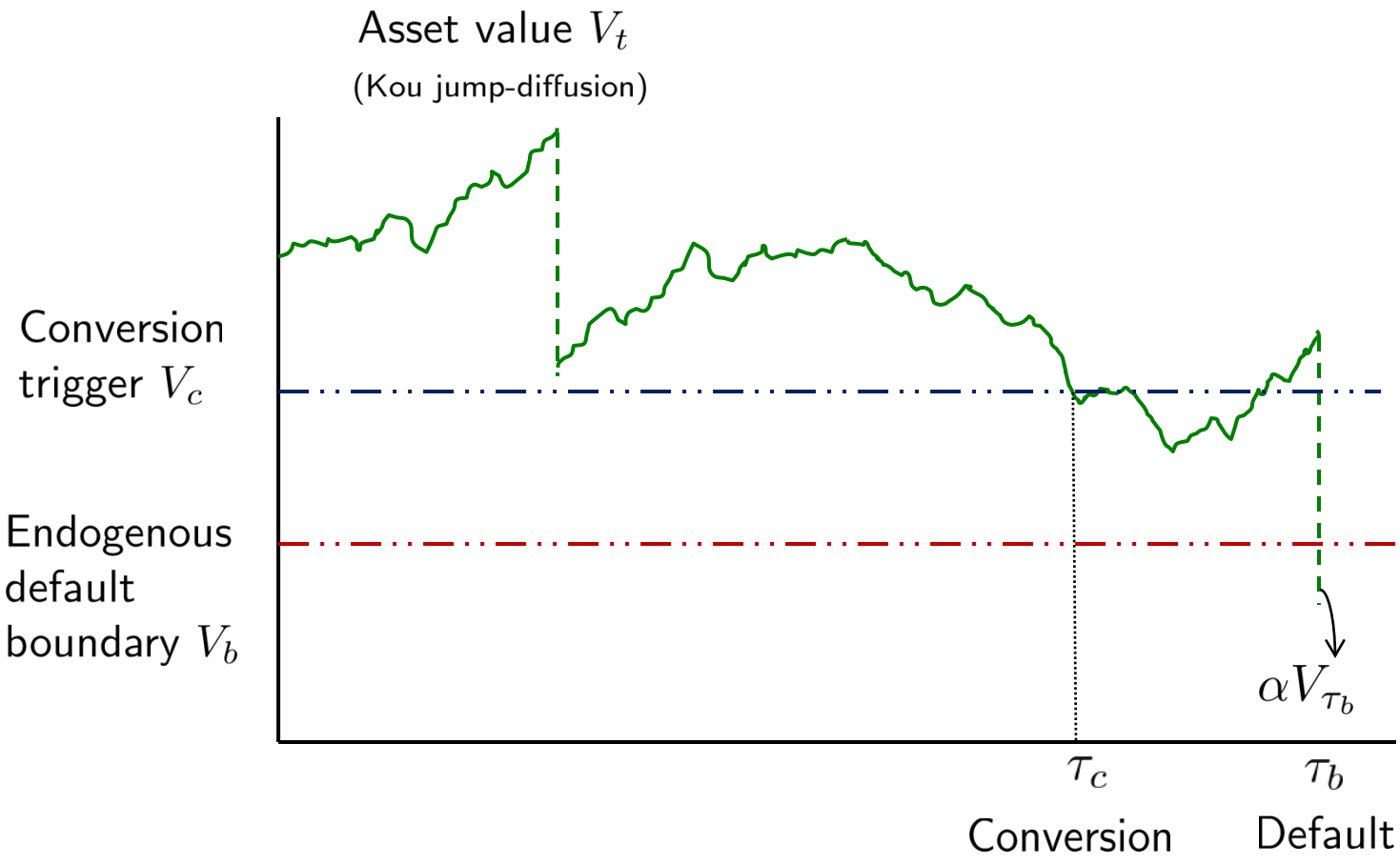
- View a firm's assets (factories, patents, or loan portfolio for a bank) as the "underlying" and value debt and equity as options on these assets
- This was the original problem of Black-Scholes (1973) and Merton (1974)



- Black and Cox (1976): The firm defaults when asset value hits a barrier
- Leland (1994): Shareholders make an optimal decision to default

Schematic of Our Model

Equity and debt valued as contingent claims on underlying asset value



Asset Value Process – Risk-Neutral Dynamics

$$\frac{dV_t}{V_{t-}} = \left(r - \delta + \frac{\lambda}{1+\eta}\right) dt + \sigma\, dW_t + d\left(\sum_{j=1}^{N_t}(Y_j - 1)\right)$$

- Payout rate δ
- Compound Poisson jump process with rate λ
- Exponential(η) distributed negative jumps – down jumps only

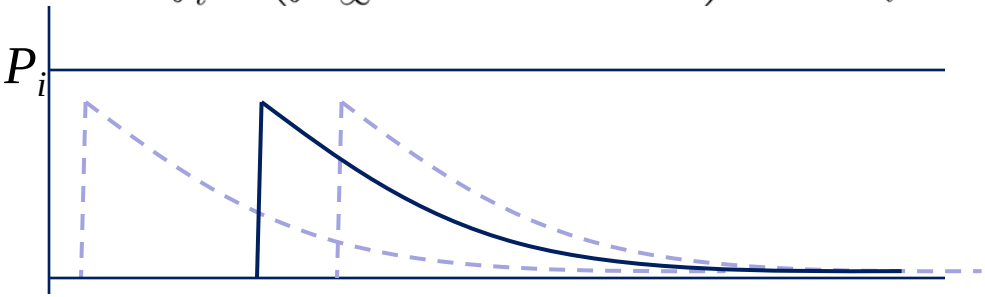
Capital Structure

- Senior debt
- [contingent convertible debt – CoCos or bail-in]
- Equity

Leland-Toft (1996) stationary maturity structure: For each debt category,

- Par value issued at rate p_i
- Exponentially distributed maturity with mean m_i
- Par value outstanding $P_i = p_i / m_i$
- Coupon rate c_i
- Interest payment rate $c_i P_i$

$$P_i = \int_t^\infty \left(\int_{-\infty}^t p_i m_i e^{-m_i(s-u)}\, du \right) ds = \frac{p_i}{m_i}.$$



Valuation

- Senior debt earns coupon and principal until default, then a partial recovery; value by discounting future cash flows
- CoCos earn coupon and principal until conversion, then a fraction of the *post-conversion* firm's equity value*

- Equity value = Total firm value – debt value

- Total firm value = Assets + present value of tax benefit of debt – present value of bankruptcy costs

- We distinguish firm and equity values BC (before conversion) and PC (post conversion)

*assuming conversion before bankruptcy

CoCo Conversion – Illustration

Assets	Liabilities
100	Debt = 60
	CoCo = 30
	Equity = 10

Asset value drops 5%

Assets	Liabilities
95	Debt = 60
	Equity = 35

Here we suppose that the conversion trigger is at 95

After conversion, the original shareholders own 1/7 of the firm

The new shareholders (converted from CoCos) own 6/7 of the firm

Senior Debt Valuation

- Suppose default boundary V_b is given (to be optimized later)
- Default time τ_b
- One unit of senior debt with maturity T has value

$$
\begin{aligned}
b(V_t;T;V_b) \quad = \quad & \mathbb{E}\left[e^{-rT}\mathbf{1}_{\{\tau_b>T+t\}}|V_t\right] \quad \text{(principal payment if no default)} \\
& +\mathbb{E}\left[e^{-r\tau_b}\mathbf{1}_{\{\tau_b\leq T+t\}}\cdot\frac{\alpha V_{\tau_b}}{P_1}\middle|V_t\right] \quad \text{(payment at default)} \\
& +\mathbb{E}\left[\int_0^{\tau_b\wedge(T+t)} c_1 e^{-r(u-t)}du\middle|V_t\right]. \quad \text{(coupon payments)}
\end{aligned}
$$

Senior Debt Valuation

- The total value of senior debt outstanding is therefore

$$
\begin{aligned}
B(V;V_b) &= P_1 \int_0^\infty b(V_t;T;V_b) m e^{-mT} dT \\
&= P_1 \left(\frac{m+c}{m+r}\right) \mathbb{E}\left[1 - e^{-(m+r)\tau_b}\right] + \mathbb{E}\left[e^{-(m+r)\tau_b} \alpha V_{\tau_b}\right].
\end{aligned}
$$

- Kou (2002) calculates the joint Laplace transform for the first passage time and the log asset value, which is what we need to evaluate the expectations

CoCo Valuation

- At conversion, CoCo investors get Δ shares per unit of debt

$$
\begin{aligned}
d(V;T;V_b) &= \mathbb{E}\left[e^{-rT}\mathbf{1}_{\{\tau_c>T\}}\right] + \mathbb{E}\left[\int_0^{T\wedge\tau_c} c_2 e^{-rs} ds\right] \\
&\quad + \frac{\Delta}{1+\Delta P_2}\mathbb{E}\left[e^{-r\tau_c}E^{\mathsf{PC}}(V_{\tau_c};V_b)\mathbf{1}_{\{\tau_c<T\}}\right]. \quad \text{(conversion value)}
\end{aligned}
$$

$E^{\mathsf{PC}}(V;V_b) =$ post-conversion value of equity with asset value V and default barrier V_b
$\tau_c =$ conversion time

$$
\begin{aligned}
D(V;V_b) &= P_2\int_0^\infty d(V;T;V_b)\, m e^{-mT} dT \\
&= P_2\left(\frac{c_2+m}{m+r}\right)\left(1-\mathbb{E}[e^{-(r+m)\tau_c}]\right) \\
&\quad + \frac{\Delta P_2}{1+\Delta P_2}\mathbb{E}[e^{-(r+m)\tau_c}E^{\mathsf{PC}}(V_{\tau_c};V_b)].
\end{aligned}
$$

Valuing The Equity And The Firm

After conversion, the firm has only one class of debt, so

$$E^{\mathsf{PC}}(V_{\tau_c}; V_b) = F^{\mathsf{PC}}(V_{\tau_c}; V_b) - B(V_{\tau_c}; V_b),$$

where $F^{\mathsf{PC}}(V_{\tau_c}; V_b)$ is the total firm value after conversion:

$$\begin{aligned} & F^{\mathsf{PC}}(V_{\tau_c}; V_b) \\ = \quad & \underbrace{V_{\tau_c}}_{\text{assetvalue}} + \underbrace{\mathbb{E}\left[\int_{\tau_c}^{\tau_b} \kappa c_1 P_1 e^{-rs} ds | V_{\tau_c}\right]}_{\text{tax benefits}} - \underbrace{\mathbb{E}\left[e^{-r(\tau_b - \tau_c)}(1-\alpha) V_{\tau_b} | V_{\tau_c}\right]}_{\text{bankruptcy costs}} \\ = \quad & V_{\tau_c} + \frac{\kappa c_1 P_1}{r}\left(1 - \mathbb{E}\left[e^{-r(\tau_b - \tau_c)} | V_{\tau_c}\right]\right) - \mathbb{E}\left[e^{-r(\tau_b - \tau_c)}(1-\alpha) V_{\tau_b} | V_{\tau_c}\right] \end{aligned}$$

κ is the firm's marginal tax rate. If coupons are tax deductible, then the tax deduction is a benefit to the firm.

Valuing The Original Firm and Its Equity

Finally, we get to the original, before-conversion firm:

$$F^{\mathsf{BC}}(V;V_b) = V + \underbrace{\frac{\kappa c_1 P_1}{r}\left(1-\mathbb{E}\left[e^{-r\tau_b}\right)\right]}_{\text{tax benefits from straight bonds}} + \underbrace{\frac{\kappa c_2 P_2}{r}\left(1-\mathbb{E}\left[e^{-r\tau_c}\right)\right]}_{\text{tax benefits from CoCos}}$$
$$-\mathbb{E}\left[e^{-r\tau_b}(1-\alpha)V_{\tau_b}\right]$$

Its equity value is given by

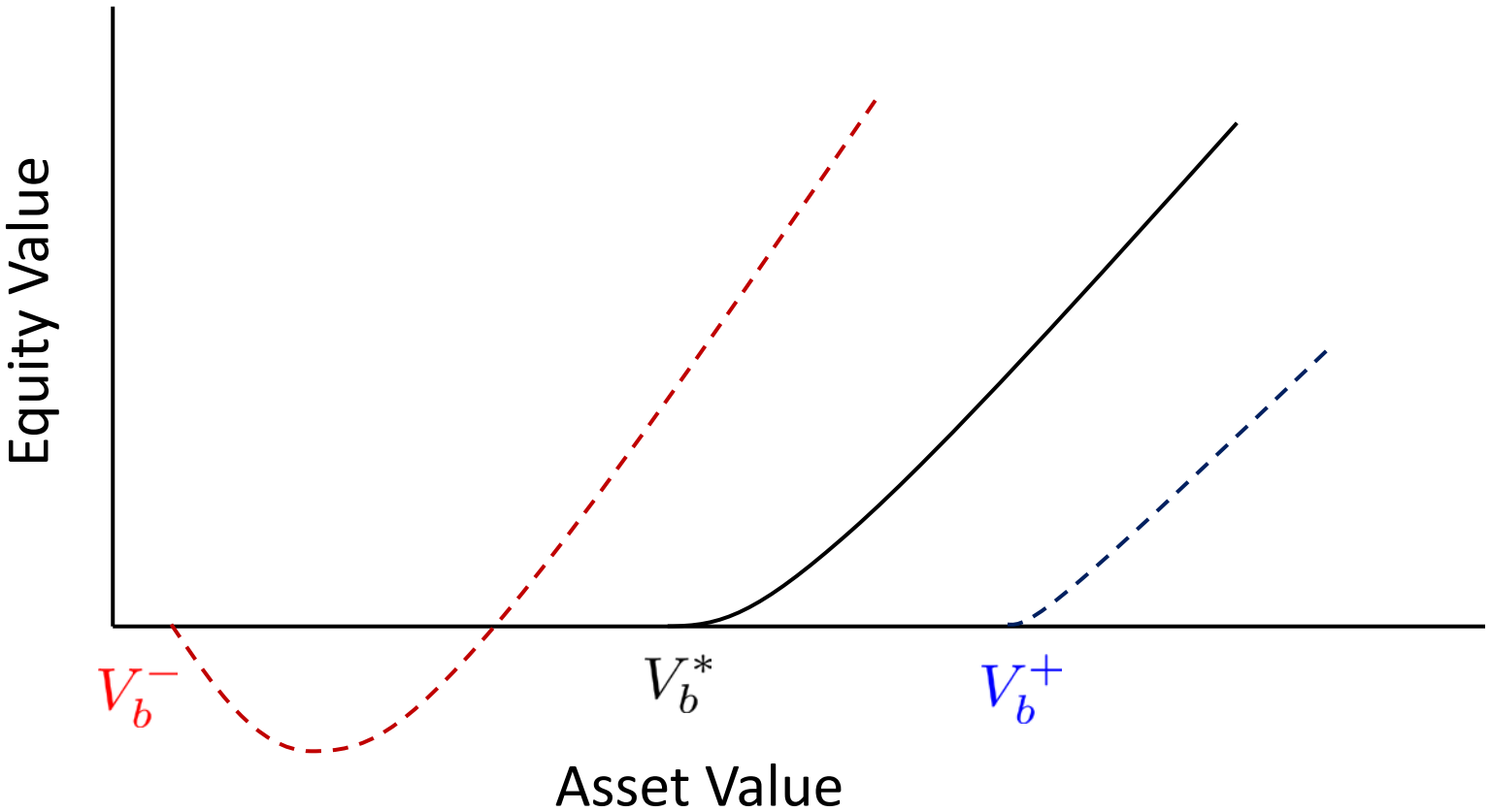
$$E^{\mathsf{BC}}(V;V_b) = F^{\mathsf{BC}}(V;V_b) - B(V;V_b) - D(V;V_b).$$

If CoCo coupons are not tax-deductible (as appears to be the case in the U.S.), omit the corresponding term.

Default Boundary and Smooth Pasting (Without CoCos)

Leland (1994), Chen-Kou (2009)

- Shareholders choose default boundary to maximize value of equity
- The optimal barrier level is characterized by smooth pasting of equity value



Endogenous Default With CoCos

- If we know that conversion will precede default
  - Then the default decision will be made by the post-conversion firm
    - For which the CoCos are irrelevant
      - So the default boundary follows the original Chen-Kou model

- But is it possible that shareholders will choose to default prior to conversion of the CoCos?

- Introduce an NC (no-conversion) firm, for which the CoCos reduce to junior debt
  - The default boundary again follows from Chen-Kou

Endogenous Default With CoCos

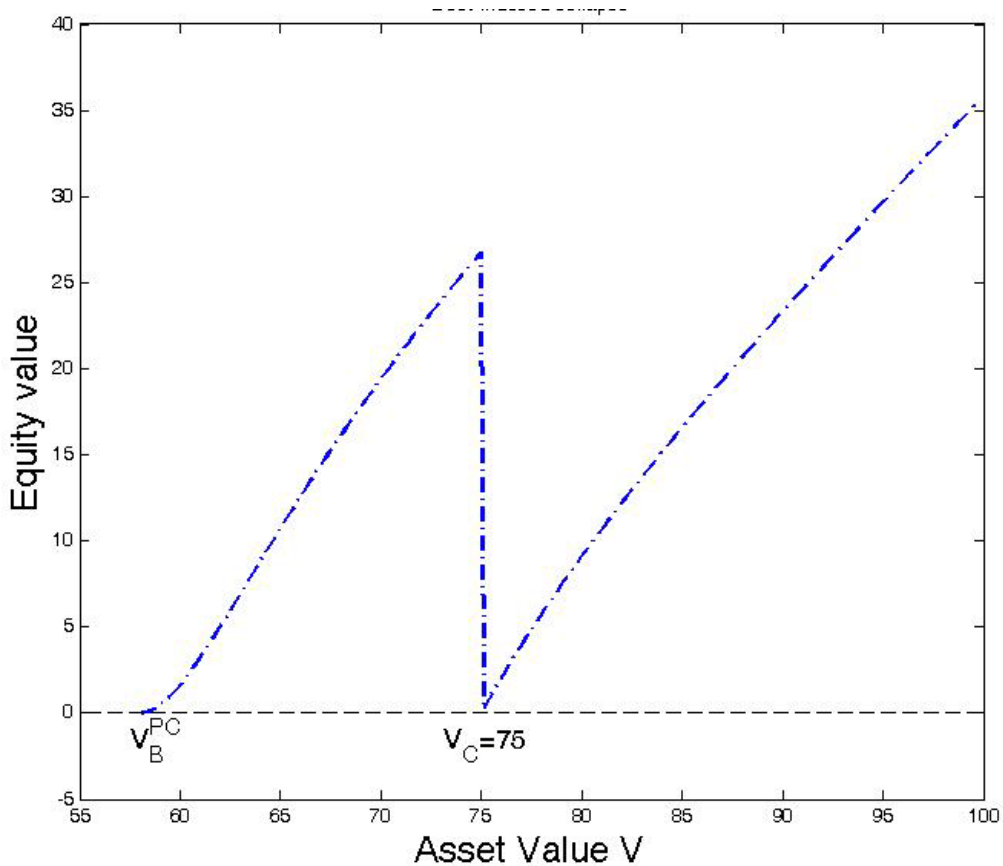
Theorem 1. For a firm with straight debt and with CoCos that convert at V_c, the optimal default barrier V_b^* has the following property: Either

$$V_b^* = V_b^{\mathsf{PC}} \leq V_c \quad \text{or} \quad V_b^* = V_b^{\mathsf{NC}} \geq V_c.$$

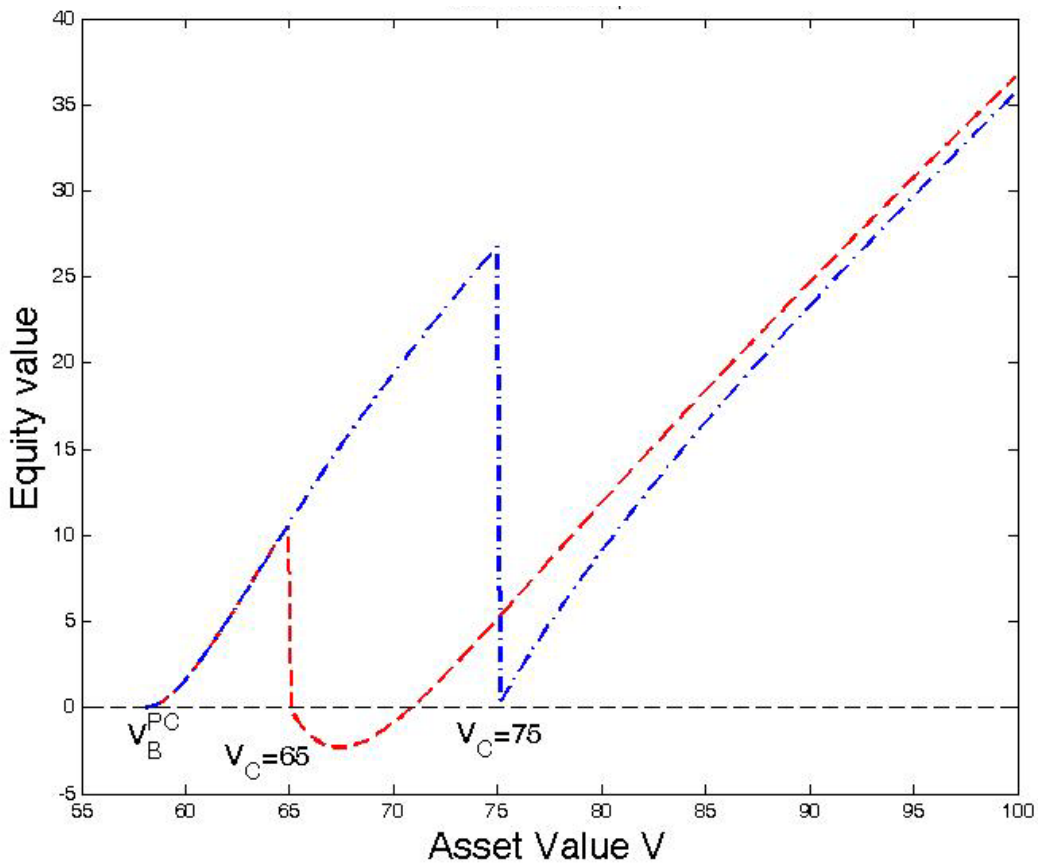
Moreover, V_b^{PC} is optimal whenever it is feasible, meaning that it preserves the limited liability of equity.

- The default barrier coincides either with that of the post-conversion or the no-conversion firm, and this determines whether conversion precedes bankruptcy
- An increase in either type of debt can move the firm from the first regime to the second, a phenomenon we call *debt-induced collapse*

Equity Value and Default: Good Case

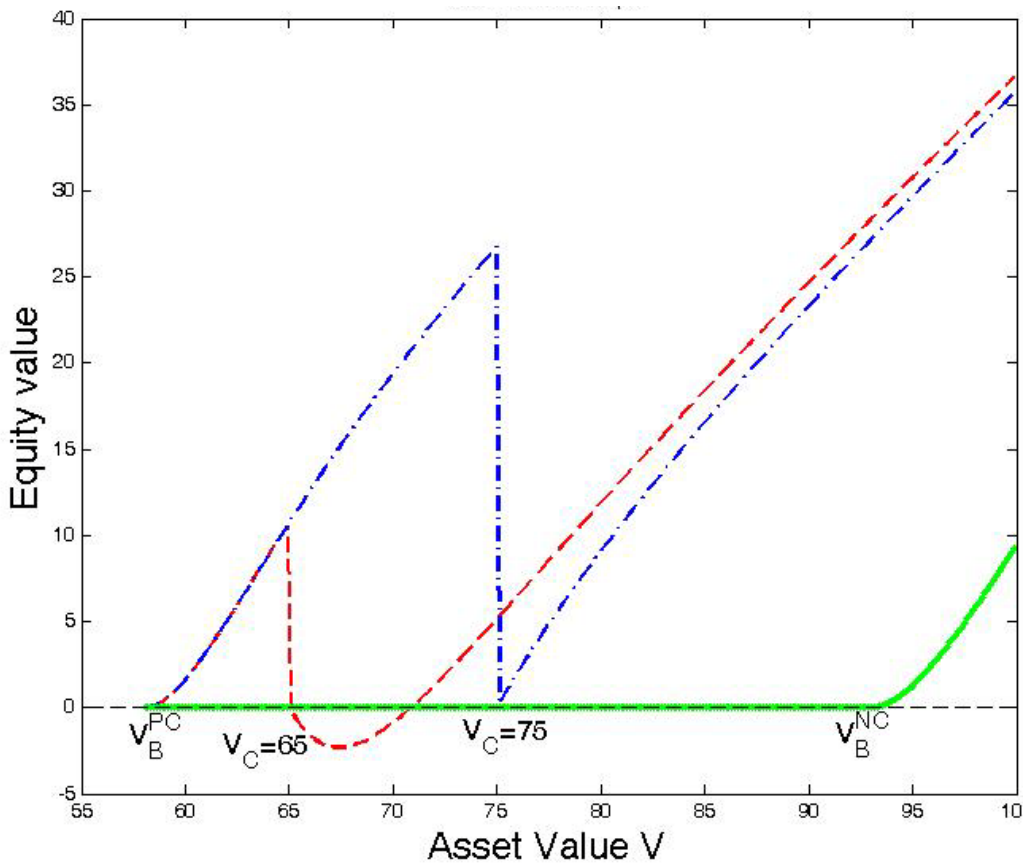


Equity Value and Default: Lower Conversion Trigger



Debt-Induced Collapse

Equity value jumps down, default risk jumps up



Before Conversion, Post-Conversion, No-Conversion

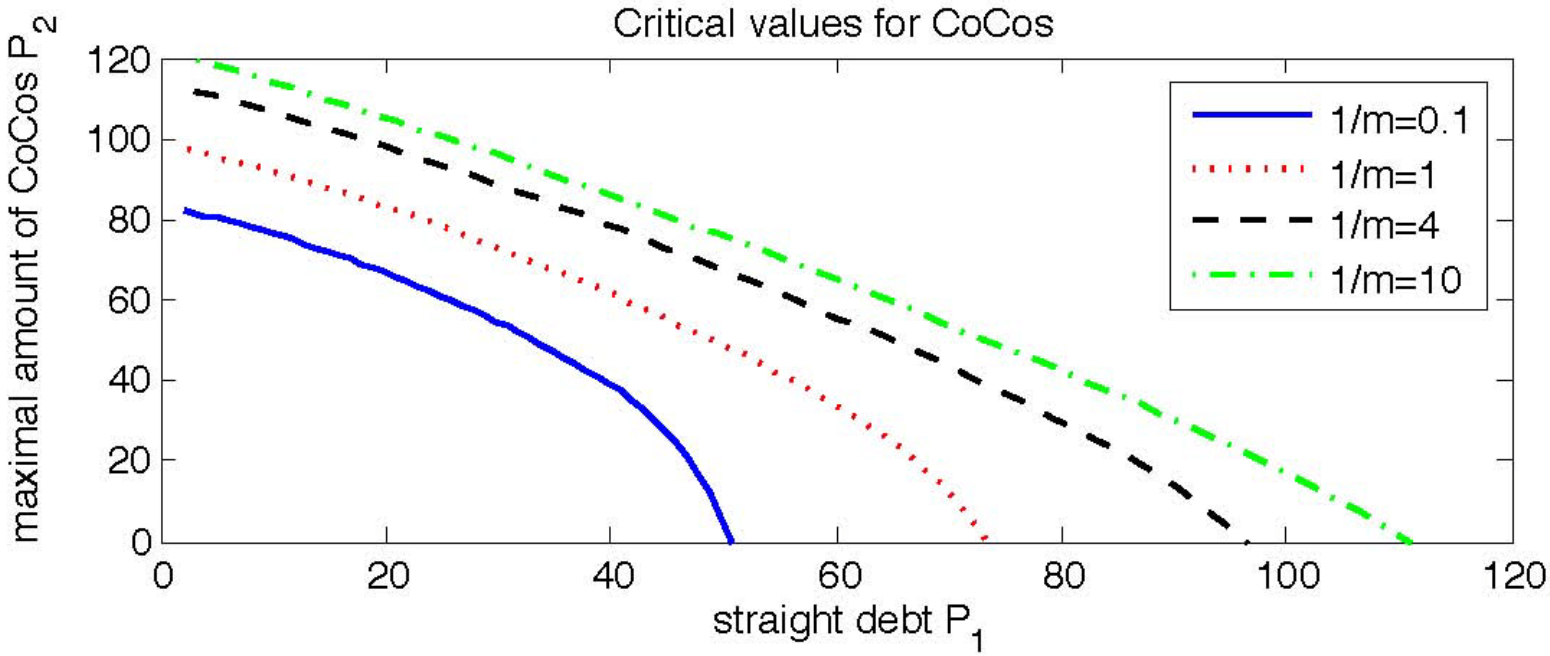
- We are interested in the default boundary for the before-conversion firm
- Once the CoCos convert (PC), we will be dealing with a conventional capital structure for which we know the default boundary V_b^{PC}
- Anticipating this situation, the BC equity holders choose the PC boundary
- *But this choice may not be feasible!*

- In which case they will choose to default before conversion

- The optimal default boundary is then the no-conversion barrier – the default level that would be chosen if the CoCos were replaced by straight debt, causing debt-induced collapse

- *Need to set the conversion trigger high enough relative to total debt*

Critical Levels of Debt for Debt-Induced Collapse



- 1/m = average debt maturity (in years)
- Total assets = 100

Incentive Effects
Once Debt-Induced Collapse is Avoided

Incentive Effects

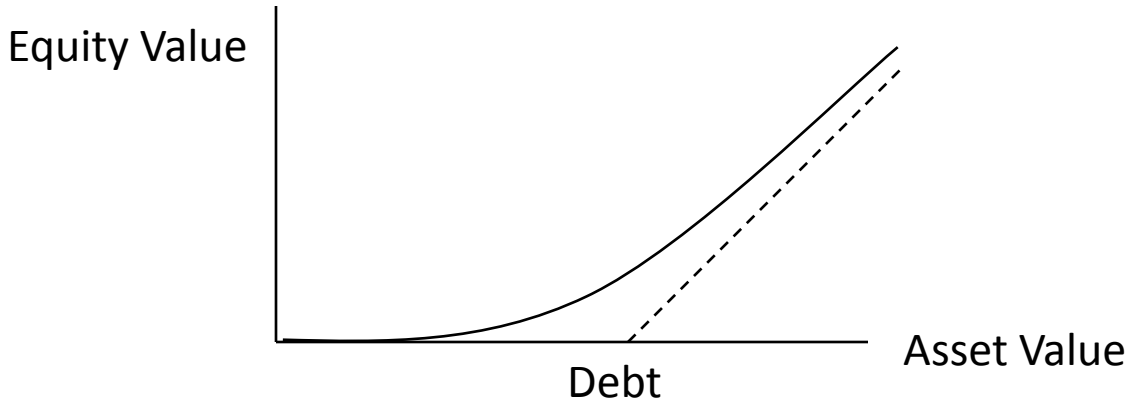
- By setting the conversion trigger sufficiently high (relative to total debt), we avoid debt-induced collapse, and the CoCos function as intended

- We can now look at incentive effects in the “good” regime

- The effects depend on the interaction between debt maturity, CoCos, and tail risk in the form of jumps
  - In particular, debt rollover allows shareholders to capture some of the benefit of reducing risk, all of which goes to bond holders in a model with a single debt maturity

Debt Overhang Costs

- Debt overhang (Myers 1977): Equity holders are unwilling to invest in a firm nearing bankruptcy because most of the value of their investment goes to creditors
- Debt overhang cost is always positive in a Black-Scholes-Merton-style model



- With debt roll-over, the reduction in default risk benefits shareholders by reducing roll-over costs. What about CoCos?

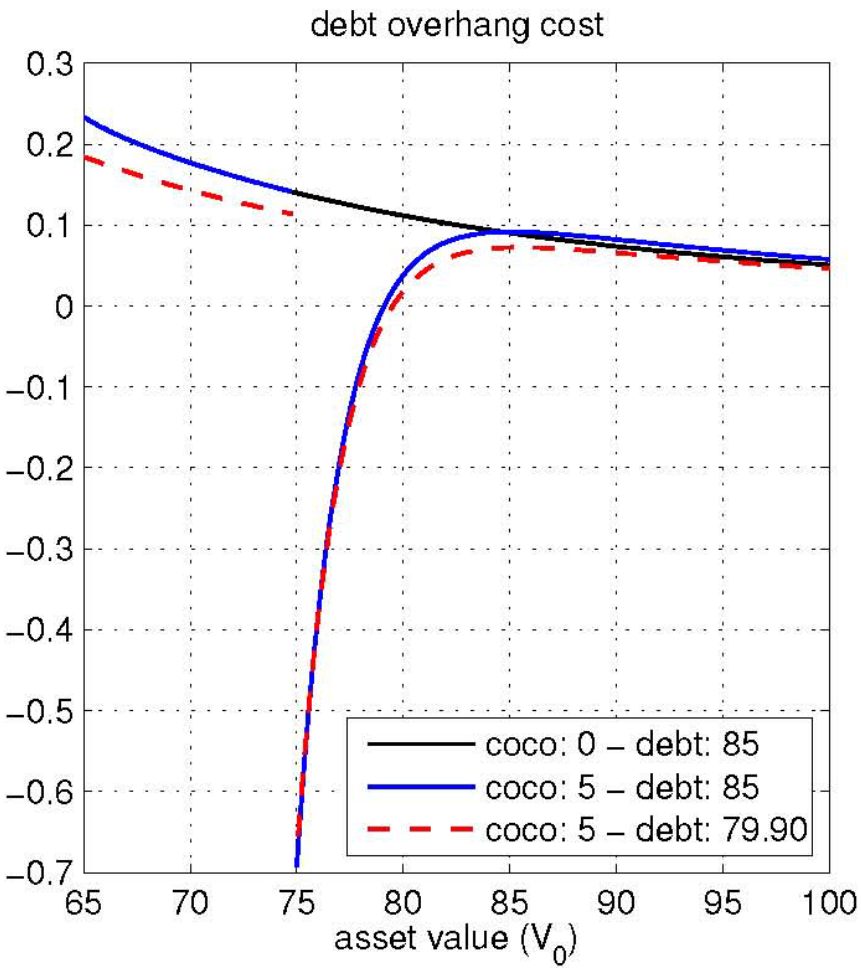
The Importance of Debt Roll-Over

- With infinite maturity debt (or in a finite-horizon model in which all debt matures at the end), the value of reducing default risk is captured by the debt holders
- Net cashflow rate

Income from assets + debt issuance – debt retirement – after-tax coupons – insurance fees

- Debt is issued at market value. Reducing default risk *raises* market value of debt and thus increases dividends to shareholders

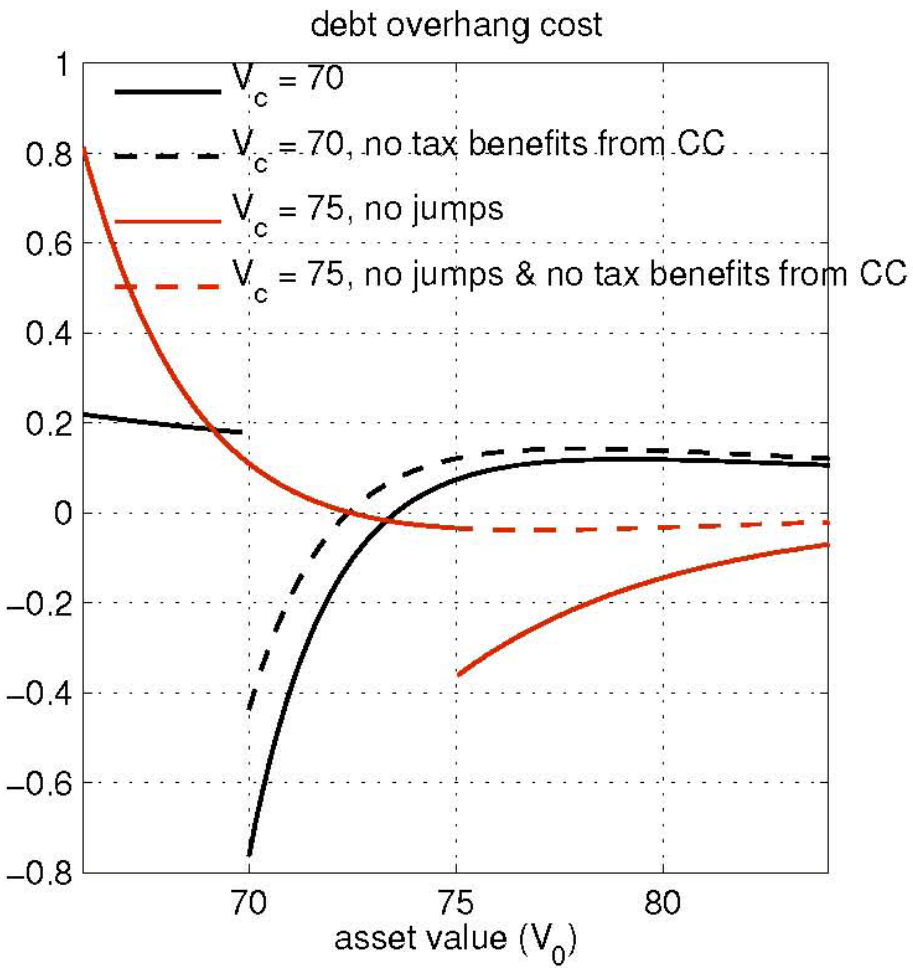
Debt Overhang Cost



- Overhang cost = investment – change in equity value
- Conversion trigger = 75
- Without CoCos, overhang cost increases as asset value decreases
- Below the trigger, CoCos are irrelevant
- Good news: Overhang cost becomes very negative as asset value approaches the trigger and equity holders try to stave off conversion
- This is an important incentive effect

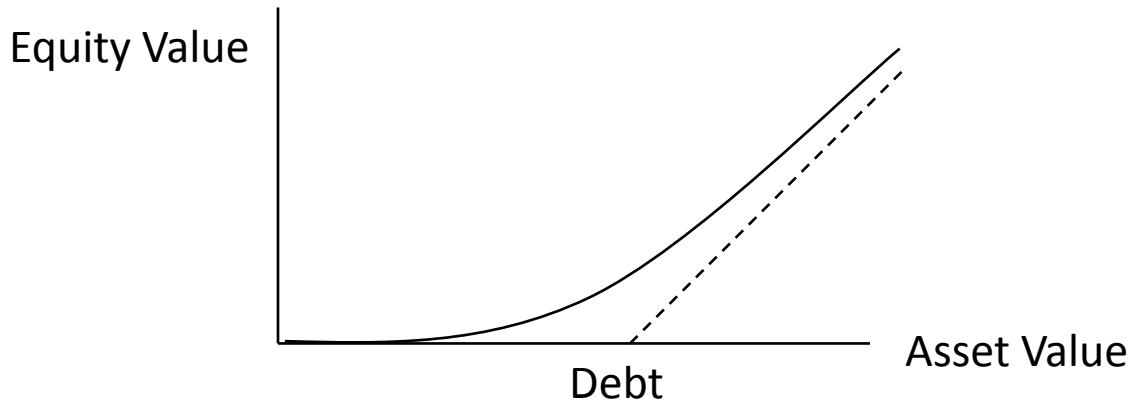
Debt Overhang Cost: A Closer Look

- Removing tax deductibility of CoCo coupons reduces investment incentive (solid vs. dashed lines)
- Bad news: Removing jumps in asset value removes about half the investment incentive
- Equity holders would rather blow up than convert at the trigger



Asset Substitution

- After equity holders issue debt, they (may) have an incentive to increase the riskiness of the assets
- This is always true in a Black-Scholes-Merton-style model of equity as a call option on assets – option value increases with volatility



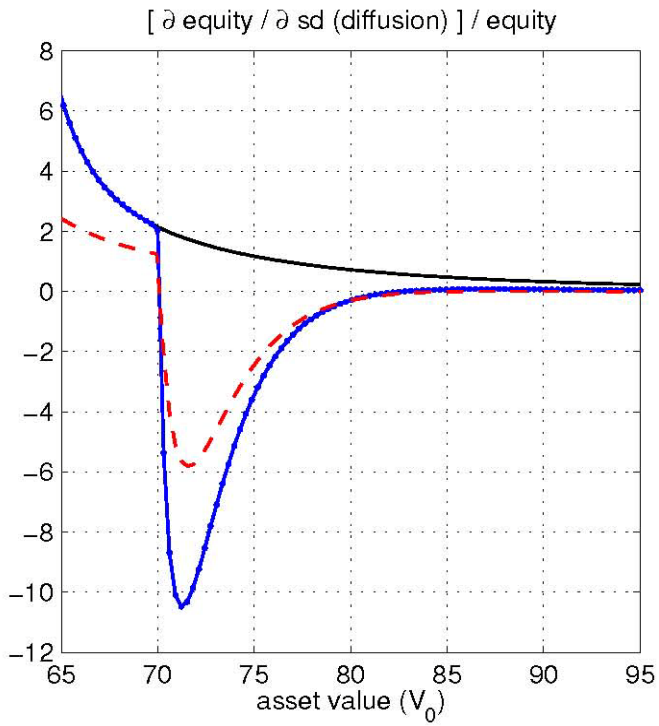
- With debt roll-over, a reduction in default risk benefits shareholders by reducing roll-over costs. What about CoCos?
- Need to consider jumps vs. diffusion and the effect of debt maturity

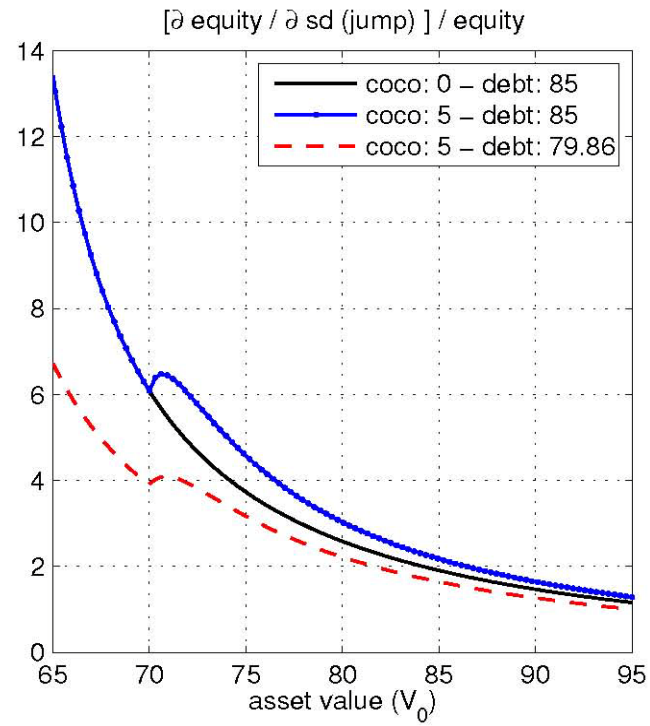
Asset Substitution

- As in a Black-Scholes-Merton model, equity holders capture the upside
  - This encourages more risk
- Riskier assets increase debt rollover costs
  - Debt is issued at market value but repaid at face value, so risk reduces dividends
  - This argues for less risk, particularly with shorter-maturity debt

- With CoCos, conversion leads to (partial) loss of tax shield
  - This argues for less risk
- Shareholders prefer conversion at a low asset level rather than a high asset level
  - This argues for less diffusion risk and more jump risk

Asset Substitution – Jumps vs. Diffusion





- Longer maturity debt – both types of risk sensitivity are positive and increasing without CoCos (black line)
- Adding CoCos (blue line) increases appetite for jump risk as it decreases appetite for diffusive risk
- When straight debt is replaced by CoCos, both risk sensitivities increase

Calibration to Banks Through the Crisis

Calibration

- Take 19 largest US bank holding companies; drop MetLife and Ally/GMAC
- Inputs
  - Market value of equity
  - Quarterly reports for deposits, short-term debt, long-term debt
  - Interest payments and dividends for payout rate
  - Risk-free rate: Treasury yield at weighted average maturity of debt
  - FISD and TRACE for market yields on debt

- Calibration
  - Need market value of assets, but this is not observable
    - We use a model-implied asset process
  - We need risk-neutral parameters of asset value process

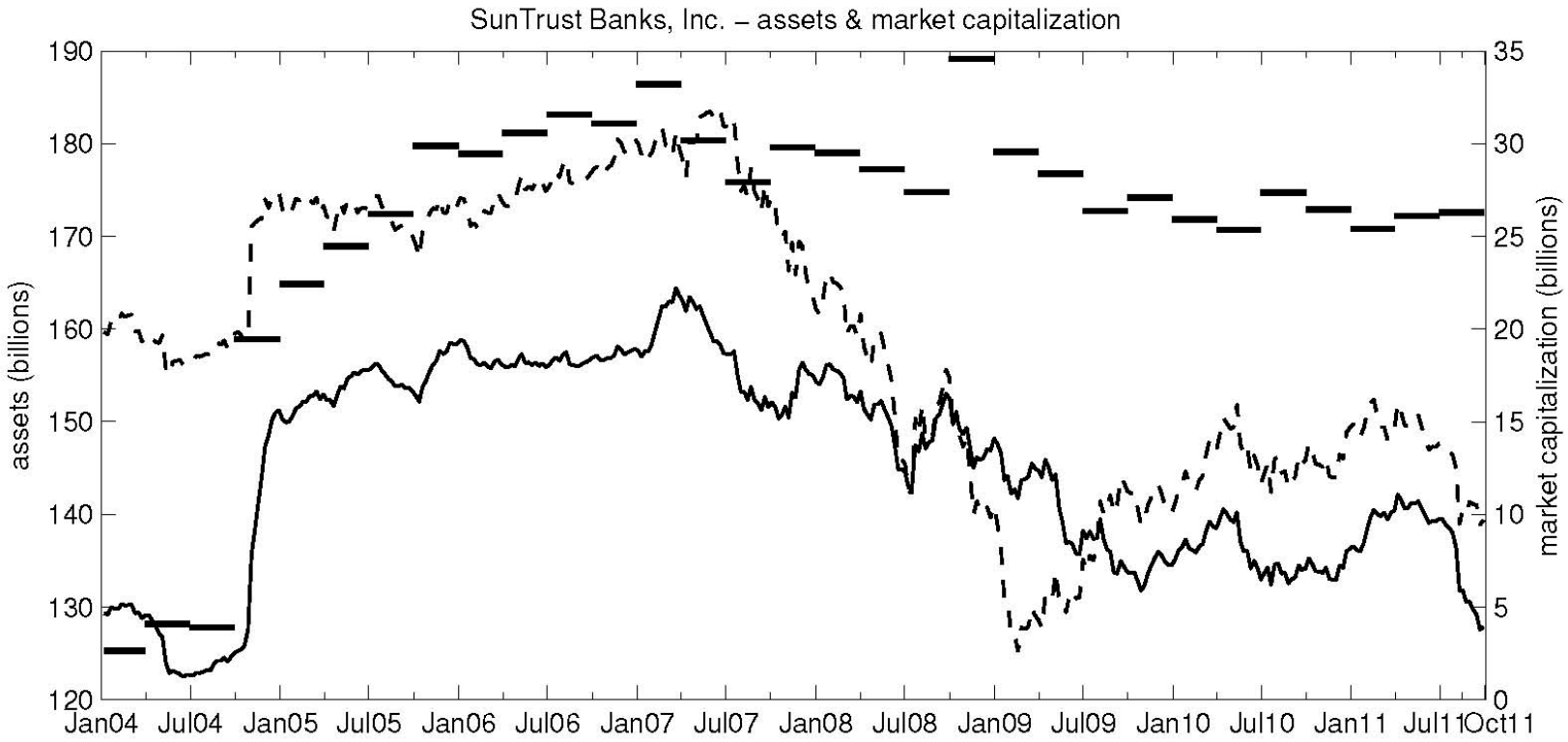
Calibration

- With all parameters fixed, we can invert model to get path of asset value from path of equity values
- With other parameters fixed, we vary σ until the annualized sample standard deviation of log returns of implied asset value matches σ
- Among all (λ, η, σ), we choose the best over a finite grid
  - Best in the sense of matching model-implied average discount on debt to market value
- Grid takes jump rate of 0.1 or 0.3 and η between 5 and 10

Calibration

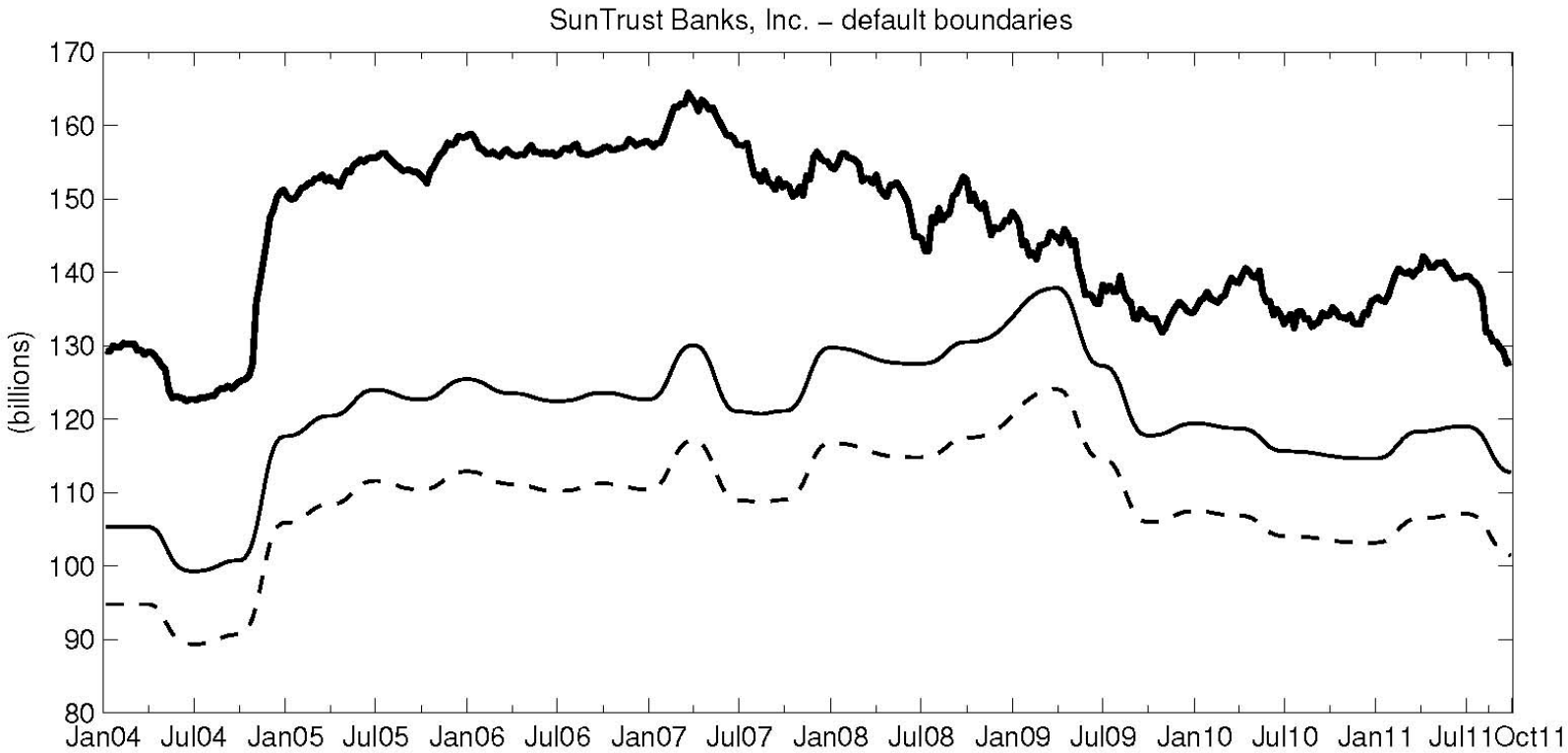
Bank Holding Company	Parameters λ	η	σ
Bank of America Corp	0.1	5	4.1%
JPMorgan Chase & Co.	0.1	8	4.4%
Citigroup Inc.	0.1	9	3.9%
Wells Fargo & Company	0.1	5	4.7%
Goldman Sachs Group, Inc.	0.1	5	3.8%
Morgan Stanley	0.1	8	4.2%
PNC Financial Services	0.3	8	7.0%
U.S. Bancorp	0.3	5	5.5%
Bank of New York Mellon Corp.	0.3	6	7.3%
SunTrust Banks, Inc.	0.3	9	4.1%
Capital One Financial Corp.	0.3	7	7.9%
BB&T Corporation	0.3	6	5.3%
Regions Financial Corporation	0.3	8	4.7%
State Street Corporation	0.3	5	7.4%
American Express Company	0.3	8	8.6%
Fifth Third Bancorp	0.3	5	6.3%
KeyCorp	0.3	8	4.2%

Example: SunTrust



- Market cap: dashed line
- Book value of assets: piecewise constant line
- Model-implied asset value: solid line

SunTrust Default Boundaries

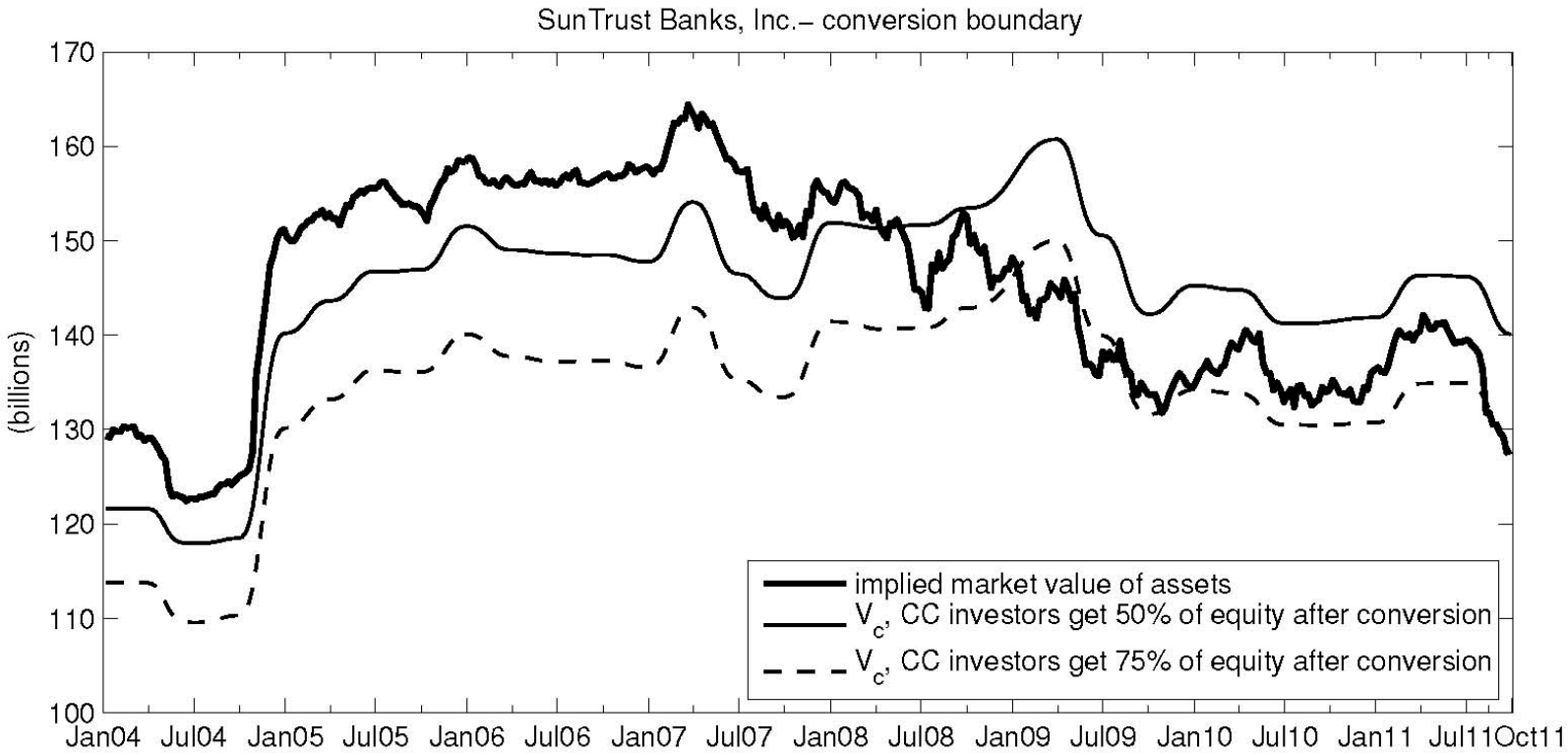


- Asset value (top)
- No-CoCo default boundary (middle)
- With-CoCo default boundary (bottom)

Loss Absorption/CoCo Size and Distance to Default

	Jan-2006		Jan-2007		Jan-2008		Jan-2009	
Bank of America Corp	1.47	7%	1.43	8%	1.63	5%	1.54	3%
JPMorgan Chase & Co.	1.29	6%	1.29	6%	1.49	5%	1.50	5%
Citigroup Inc.	1.34	7%	1.32	6%	1.42	4%	-	2%
Wells Fargo & Company	1.11	19%	1.06	22%	1.44	9%	1.60	5%
Goldman Sachs Group, Inc.	1.35	4%	1.41	5%	1.52	4%	-	4%
Morgan Stanley	1.43	4%	1.38	4%	1.50	5%	-	5%
PNC Financial Services	1.17	19%	1.11	21%	1.29	14%	-	8%
U.S. Bancorp	0.95	32%	0.98	32%	1.11	24%	1.17	18%
Bank of New York Mellon	1.15	24%	1.06	28%	1.04	28%	0.80	17%
SunTrust Banks, Inc.	0.91	21%	0.87	22%	0.91	16%	-	8%
Capital One Financial Corp.	0.93	29%	0.92	26%	0.97	16%	-	12%
BB&T Corporation	1.03	25%	1.03	23%	0.97	14%	-	9%
Regions Financial Corp.	0.90	24%	0.89	19%	0.87	12%	-	4%
State Street Corporation	1.33	18%	1.25	20%	1.07	24%	-	11%
American Express Company	1.15	38%	1.13	36%	1.26	28%	1.50	18%
Fifth Third Bancorp	0.89	26%	0.77	31%	-	17%	-	6%
KeyCorp	1.11	17%	1.01	20%	-	10%	-	5%
mean	1.15	18.81%	1.11	19.23%	1.23	13.73%	1.35	8.15%
median	1.15	19.32%	1.06	20.52%	1.26	13.80%	1.50	5.81%

SunTrust Conversion Triggers

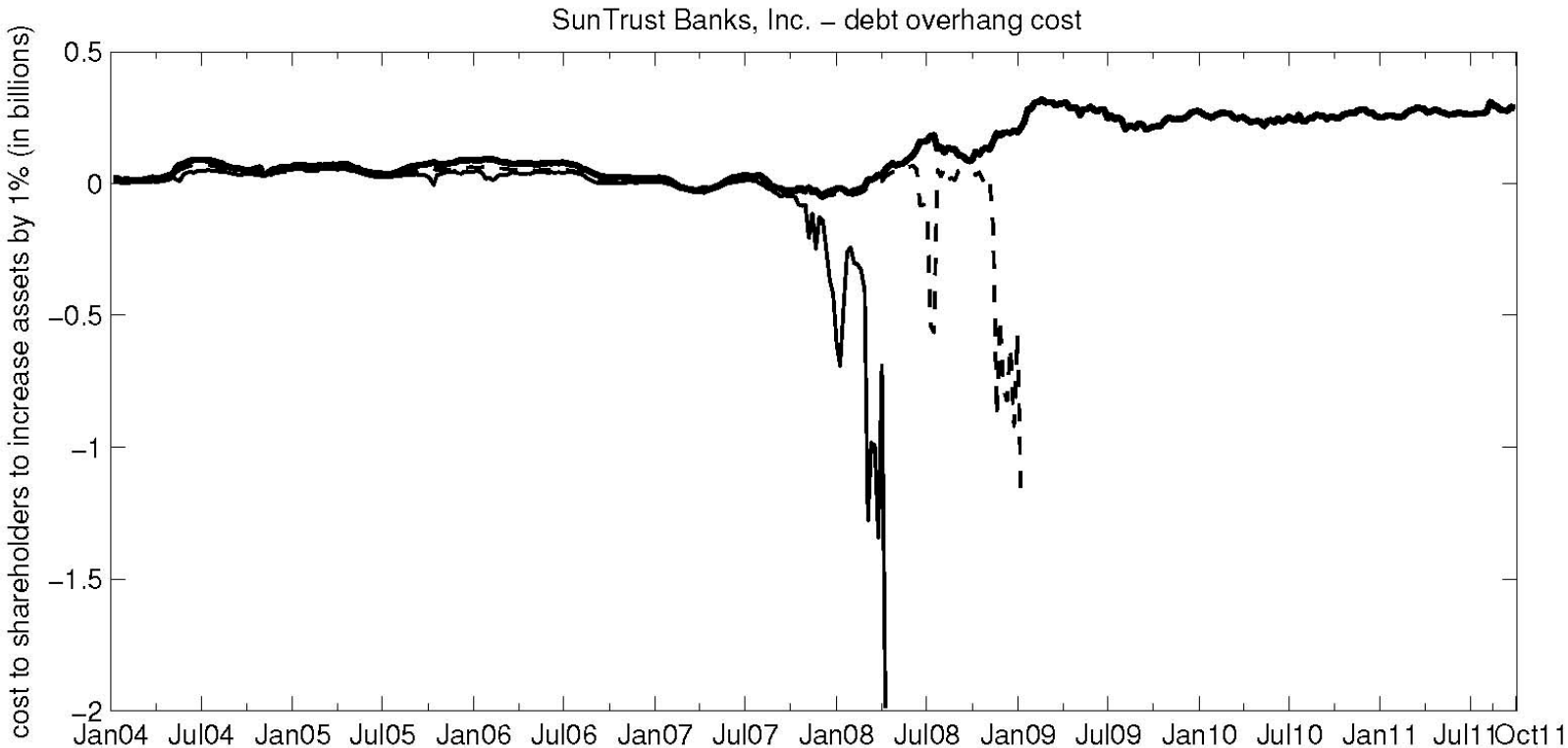


- Asset value
- Conversion trigger with 50% dilution
- Conversion trigger with 75% dilution

Conversion Dates

Bank Holding Company	Parameters λ	η	σ	Conversion Date 50%	75%
Bank of America Corp	0.1	5	4.1%	Jan-09	
JPMorgan Chase & Co.	0.1	8	4.4%		
Citigroup Inc.	0.1	9	3.9%	Nov-08	
Wells Fargo & Company	0.1	5	4.7%		
Goldman Sachs Group, Inc.	0.1	5	3.8%	Nov-08	
Morgan Stanley	0.1	8	4.2%	Sep-08	Dec-08
PNC Financial Services	0.3	8	7.0%	Nov-08	Jan-09
U.S. Bancorp	0.3	5	5.5%	Jan-09	
Bank of New York Mellon Corp.	0.3	6	7.3%	Oct-08	
SunTrust Banks, Inc.	0.3	9	4.1%	Apr-08	Jan-09
Capital One Financial Corp.	0.3	7	7.9%	Jun-08	Jan-09
BB&T Corporation	0.3	6	5.3%	Jun-08	
Regions Financial Corporation	0.3	8	4.7%	Jun-08	Jan-09
State Street Corporation	0.3	5	7.4%	Oct-08	
American Express Company	0.3	8	8.6%		
Fifth Third Bancorp	0.3	5	6.3%	Jan-08	Jun-08
KeyCorp	0.3	8	4.2%	Nov-07	Nov-08

SunTrust Debt Overhang Cost



- Cost to increase asset value by 1%
- Drops sharply (becoming negative) near conversion

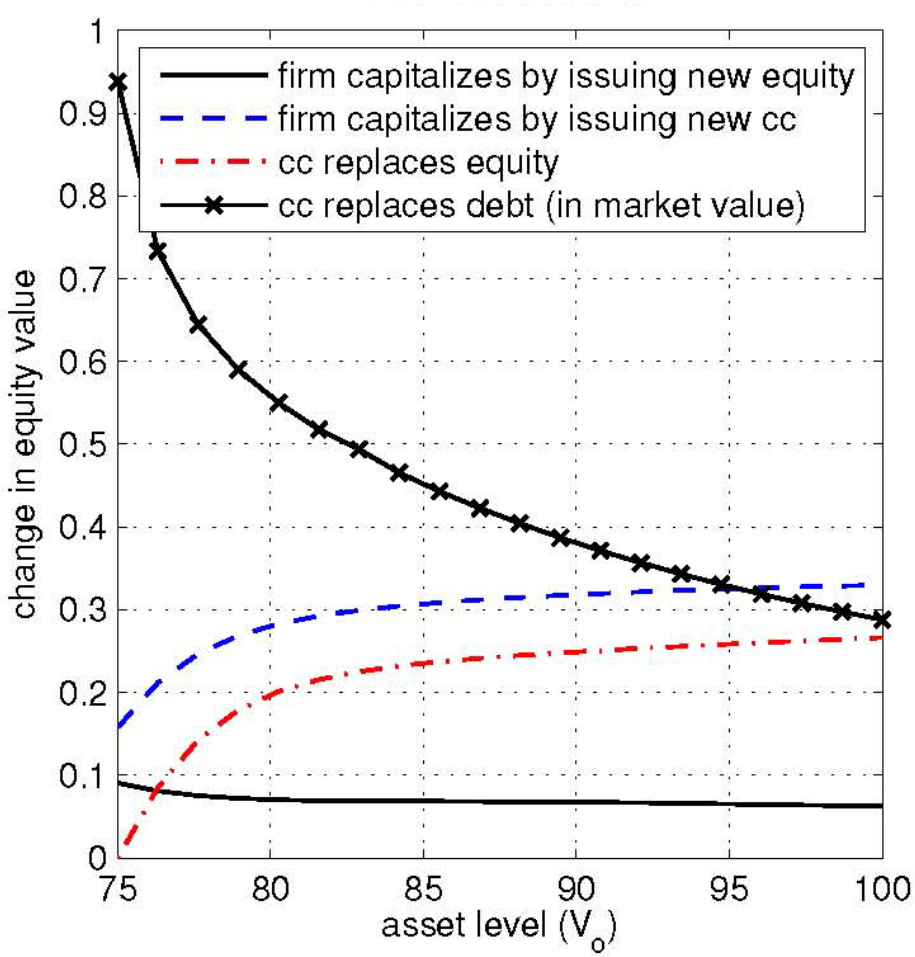
Debt Overhang Cost Without/With CoCos and Distance to Conversion

	Feb-2008			Apr-2008			Aug-2008		
Bank of America Corp	-29%	-32%	6%	-26%	-30%	5%	-28%	-42%	3%
JPMorgan Chase & Co.	-75%	-51%	5%	-43%	-41%	5%	-93%	-60%	3%
Citigroup Inc.	-42%	-53%	3%	-24%	-45%	2%	-54%	-65%	2%
Wells Fargo & Company	-35%	-23%	8%	-33%	-20%	8%	-33%	-21%	7%
Goldman Sachs Group	-51%	-45%	2%	-33%	-42%	2%	-53%	-54%	2%
Morgan Stanley	21%	-42%	1%	21%	-36%	1%	-20%	-58%	2%
PNC Financial Services	-11%	-16%	7%	-7%	-12%	8%	-10%	-12%	8%
U.S. Bancorp	4%	4%	13%	5%	5%	13%	5%	5%	11%
Bank of New York Mellon	-3%	-2%	17%	-1%	0%	14%	6%	4%	8%
SunTrust Banks, Inc.	-2%	-20%	2%	5%	-	-	9%	-	-
Capital One Financial	-4%	-28%	3%	4%	-34%	2%	6%	-	-
BB&T Corporation	2%	-11%	4%	4%	-12%	4%	6%	-60%	1%
Regions Financial Corp.	-7%	-24%	3%	-8%	-42%	2%	-9%	-	-
State Street Corporation	2%	2%	11%	5%	-1%	6%	0%	-11%	5%
American Express Co.	-12%	-13%	20%	-7%	-10%	20%	-10%	-12%	17%
Fifth Third Bancorp	12%	-79%	0%	17%	-	-	19%	-	-
KeyCorp	-6%	-137%	0%	-1%	-	-	5%	-	-

Summary and Concluding Remarks

- We've developed a jump-diffusion capital structure model to value contingent capital in the form of CoCos and bail-in debt
- The interactions between endogenous default, debt rollover, and jumps in asset value have significant impact on the functioning of CoCos
- Main observations
  - Trigger needs to be high enough to avoid debt-induced collapse
  - Because equity holders capture some of the benefit of reduced bankruptcy costs, they often have a positive incentive to issue CoCos
  - CoCos reduce debt overhang costs near conversion
  - Reduce appetite for asset volatility, but can increase appeal of tail risk
  - Calibration to bank data suggests that CoCos would have had positive effects through the crisis

Example: Unit Change or Addition to Liabilities



- 1-for-1 replacement or addition
- Conversion trigger 75
- -x- line shows replacement of debt with CoCo
- Increased value of equity is greatest near the trigger
- The risk of dilution from conversion is outweighed by reduced bankruptcy cost
- At lower asset levels, replacement looks better than new equity, new CoCos, or replacing equity with CoCos