PIMS Summer School on Systemic Risk

Introduction

Paul Glasserman
Columbia Business School

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?
Overview

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

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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?
  – 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?
CoCos, Tail Risk, and Debt-Induced Collapse

Paul Glasserman
Columbia Business School

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

<table>
<thead>
<tr>
<th>Assets</th>
<th>Liabilities</th>
</tr>
</thead>
<tbody>
<tr>
<td>100</td>
<td>Debt = 90</td>
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<tr>
<td></td>
<td>Equity = 10</td>
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Asset value drops 15%

<table>
<thead>
<tr>
<th>Assets</th>
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<tbody>
<tr>
<td>85</td>
<td>Debt = 85</td>
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<td>Equity = 0</td>
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Firm is bankrupt and/or government steps in to compensate debt holders
# CoCo Conversion – Illustration

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

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<tr>
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<tr>
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<tr>
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<td>CoCo = 30</td>
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<td>Equity = 10</td>
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Asset value drops 15%

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</tr>
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<tbody>
<tr>
<td>85</td>
<td>Debt = 60</td>
</tr>
<tr>
<td></td>
<td>Equity = 25</td>
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</tbody>
</table>

Firm survives. Original shareholders lose everything, CoCo investors become shareholders
2014 On Track To See Record Issuance

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

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

Source: Financial Times
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 Tchistyj (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.
Schematic of Our Model

Equity and debt valued as contingent claims on underlying asset value

Asset value $V_t$
(Kou jump-diffusion)

Conversion trigger $V_c$

Endogenous default boundary $V_b$

$\alpha V_{\tau_b}$

Conversion $\tau_c$

Default $\tau_b$
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 $\delta$
- Compound Poisson jump process with rate $\lambda$
- Exponential($\eta$) 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

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Asset value drops 5%

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</tr>
<tr>
<td></td>
<td>Equity = 35</td>
</tr>
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</table>

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 $\tau_b$
- One unit of senior debt with maturity $T$ has value

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

• The total value of senior debt outstanding is therefore

\[ B(V; V_b) = P_1 \int_0^\infty b(V_t; T; V_b) me^{-mT} dT \]

\[ = P_1 \left( \frac{m + c}{m + r} \right) \mathbb{E} \left[ 1 - e^{-(m+r)\tau_b} \right] + \mathbb{E} \left[ e^{-(m+r)\tau_b} \alpha V_{\tau_b} \right]. \]

• 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 $\Delta$ shares per unit of debt

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

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

$\tau_c = \text{conversion time}$

\[
D(V; V_b) = P_2 \int_0^\infty d(V; T; V_b) me^{-mT} dT
\]

\[
= P_2 \left( \frac{c_2 + m}{m + r} \right) \left( 1 - \mathbb{E}[e^{-(r+m)\tau_c}] \right) + \frac{\Delta P_2}{1 + \Delta P_2} \mathbb{E}[e^{-(r+m)\tau_c} E^{PC}(V_{\tau_c}; V_b)].
\]
Valuing The Equity And The Firm

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

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

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

$$F^{PC}(V_{\tau_c}; V_b)$$

$$= V_{\tau_c} + \underbrace{\mathbb{E} \left[ \int_{\tau_c}^{\tau_b} \kappa c_1 P_1 e^{-r s} ds | V_{\tau_c} \right]}_{\text{asset value}} - \mathbb{E} \left[ e^{-r(\tau_b - \tau_c)} (1 - \alpha) V_{\tau_b} | V_{\tau_c} \right]$$

$$= V_{\tau_c} + \frac{\kappa c_1 P_1}{r} \left( 1 - \mathbb{E} \left[ e^{-r(\tau_b - \tau_c)} | V_{\tau_c} \right] \right) - \mathbb{E} \left[ e^{-r(\tau_b - \tau_c)} (1 - \alpha) V_{\tau_b} | V_{\tau_c} \right]$$

$\kappa$ 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:

\[
F^{BC}(V; V_b) = V + \frac{\kappa c_1 P_1}{r} (1 - \mathbb{E}[e^{-r\tau_b}]) + \frac{\kappa c_2 P_2}{r} (1 - \mathbb{E}[e^{-r\tau_c}])
\]

\[\text{tax benefits from straight bonds} \quad \text{tax benefits from CoCos}\]

\[-\mathbb{E}[e^{-r\tau_b}(1 - \alpha) V_{\tau_b}]\]

Its equity value is given by

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

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)

- 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

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

Moreover, $V^\text{PC}_b$ 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

![Graph showing the relationship between equity value and asset value.]
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

- $1/m = \text{average debt maturity (in years)}$
- 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.

\[
\begin{array}{c|c}
\text{Asset Value} & \text{Equity Value} \\
\hline
\text{Debt} & \text{roll-over costs}
\end{array}
\]

- 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

\[
\text{Income from assets + debt issuance - debt retirement - after-tax coupons - insurance fees}
\]

• 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 $\sigma$ until the annualized sample standard deviation of log returns of implied asset value matches $\sigma$.

• Among all $(\lambda, \eta, \sigma)$, 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 $\eta$ between 5 and 10.
## Calibration

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

<table>
<thead>
<tr>
<th>Bank Name</th>
<th>Jan-2006</th>
<th>Jan-2007</th>
<th>Jan-2008</th>
<th>Jan-2009</th>
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<td>1.43</td>
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<tr>
<td>JPMorgan Chase &amp; Co.</td>
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<tr>
<td>Citigroup Inc.</td>
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<td>1.32</td>
<td>1.42</td>
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<tr>
<td>Wells Fargo &amp; Company</td>
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<td>1.03</td>
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<td>0.89</td>
<td>0.87</td>
<td>-</td>
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<td>1.25</td>
<td>1.07</td>
<td>-</td>
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<td>1.13</td>
<td>1.26</td>
<td>1.50</td>
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<tr>
<td>KeyCorp</td>
<td>1.11</td>
<td>1.01</td>
<td>-</td>
<td>-</td>
</tr>
</tbody>
</table>

- **mean**
  - Jan-2006: 1.15, 18.81%
  - Jan-2007: 1.11, 19.23%
  - Jan-2008: 1.23, 13.73%
  - Jan-2009: 1.35, 8.15%

- **median**
  - Jan-2006: 1.15, 19.32%
  - Jan-2007: 1.06, 20.52%
  - Jan-2008: 1.26, 13.80%
  - Jan-2009: 1.50, 5.81%
SunTrust Conversion Triggers

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

<table>
<thead>
<tr>
<th>Bank Holding Company</th>
<th>Parameters</th>
<th>Conversion Date</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$\lambda$</td>
<td>$\eta$</td>
</tr>
<tr>
<td>Bank of America Corp</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>JPMorgan Chase &amp; Co.</td>
<td>0.1</td>
<td>8</td>
</tr>
<tr>
<td>Citigroup Inc.</td>
<td>0.1</td>
<td>9</td>
</tr>
<tr>
<td>Wells Fargo &amp; Company</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>Goldman Sachs Group, Inc.</td>
<td>0.1</td>
<td>5</td>
</tr>
<tr>
<td>Morgan Stanley</td>
<td>0.1</td>
<td>8</td>
</tr>
<tr>
<td>PNC Financial Services</td>
<td>0.3</td>
<td>8</td>
</tr>
<tr>
<td>U.S. Bancorp</td>
<td>0.3</td>
<td>5</td>
</tr>
<tr>
<td>Bank of New York Mellon Corp.</td>
<td>0.3</td>
<td>6</td>
</tr>
<tr>
<td>SunTrust Banks, Inc.</td>
<td>0.3</td>
<td>9</td>
</tr>
<tr>
<td>Capital One Financial Corp.</td>
<td>0.3</td>
<td>7</td>
</tr>
<tr>
<td>BB&amp;T Corporation</td>
<td>0.3</td>
<td>6</td>
</tr>
<tr>
<td>Regions Financial Corporation</td>
<td>0.3</td>
<td>8</td>
</tr>
<tr>
<td>State Street Corporation</td>
<td>0.3</td>
<td>5</td>
</tr>
<tr>
<td>American Express Company</td>
<td>0.3</td>
<td>8</td>
</tr>
<tr>
<td>Fifth Third Bancorp</td>
<td>0.3</td>
<td>5</td>
</tr>
<tr>
<td>KeyCorp</td>
<td>0.3</td>
<td>8</td>
</tr>
</tbody>
</table>
• Cost to increase asset value by 1%
• Drops sharply (becoming negative) near conversion
## Debt Overhang Cost Without/With CoCos and Distance to Conversion

<table>
<thead>
<tr>
<th>Bank</th>
<th>Feb-2008</th>
<th>Apr-2008</th>
<th>Aug-2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Bank of America Corp</td>
<td>-29%</td>
<td>-26%</td>
<td>-28%</td>
</tr>
<tr>
<td>JPMorgan Chase &amp; Co.</td>
<td>-75%</td>
<td>-43%</td>
<td>-93%</td>
</tr>
<tr>
<td>Citigroup Inc.</td>
<td>-42%</td>
<td>-24%</td>
<td>-54%</td>
</tr>
<tr>
<td>Wells Fargo &amp; Company</td>
<td>-35%</td>
<td>-33%</td>
<td>-33%</td>
</tr>
<tr>
<td>Goldman Sachs Group</td>
<td>-51%</td>
<td>-33%</td>
<td>-53%</td>
</tr>
<tr>
<td>Morgan Stanley</td>
<td>21%</td>
<td>21%</td>
<td>-20%</td>
</tr>
<tr>
<td>PNC Financial Services</td>
<td>-11%</td>
<td>-7%</td>
<td>-10%</td>
</tr>
<tr>
<td>U.S. Bancorp</td>
<td>4%</td>
<td>5%</td>
<td>5%</td>
</tr>
<tr>
<td>Bank of New York Mellon</td>
<td>-3%</td>
<td>-1%</td>
<td>6%</td>
</tr>
<tr>
<td>SunTrust Banks, Inc.</td>
<td>-2%</td>
<td>5%</td>
<td>9%</td>
</tr>
<tr>
<td>Capital One Financial</td>
<td>-4%</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>BB&amp;T Corporation</td>
<td>2%</td>
<td>4%</td>
<td>6%</td>
</tr>
<tr>
<td>Regions Financial Corp.</td>
<td>-7%</td>
<td>-8%</td>
<td>-9%</td>
</tr>
<tr>
<td>State Street Corporation</td>
<td>2%</td>
<td>5%</td>
<td>0%</td>
</tr>
<tr>
<td>American Express Co.</td>
<td>-12%</td>
<td>-7%</td>
<td>-10%</td>
</tr>
<tr>
<td>Fifth Third Bancorp</td>
<td>12%</td>
<td>17%</td>
<td>19%</td>
</tr>
<tr>
<td>KeyCorp</td>
<td>-6%</td>
<td>-1%</td>
<td>5%</td>
</tr>
</tbody>
</table>
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