MOODY'S
ANALYTICS

Best Practices for Stress Testing your Private Firm C&I Portfolio

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Originally presented and recorded as a Moody's Analytics webinar | July 2013

Agenda

- **Overview and impact(s) of stress testing**
- **Risk management and stress testing for private C&I portfolio**
- **RiskCalc™ Plus stress testing solutions**
  - **PD & LGD Approach**
  - **Ratio Based Approach**
- **Q&A**

1

Overview and Impact(s) of Stress Testing

Christian Henkel, Director – Enterprise Risk Services

As a result of the financial crisis, the Fed has adopted rules for stress testing and, in turn, capital adequacy

- Regulators now expect banks to demonstrate they will be able hold sufficient capital to enable them to continue lending even under adverse economic conditions
- Accordingly, stress testing is a tool that helps banks and supervisors measure capital adequacy through periods of stressed economic conditions
- The Dodd-Frank Wall Street Reform and Consumer Protection Act ("Dodd-Frank") requires annual stress tests for banks with assets greater than $10b:
  - Comprehensive Capital Analysis and Review ("CCAR") for the top (18) BHCs
  - Capital Plan Review ("CapPR") for non-CCAR BHCs > $50b
  - Banks $10b - $50b
- The stress test cycle (year) is the period between October 1st and September 30th; with the requirements for non-CCAR banks coming into play this fall

"A company will be required to calculate for each scenario, over each quarter of the planning horizon, pre-provision net revenue, losses, provision for loan and lease losses, and net income; and the potential impact of the scenarios on pro forma regulatory capital levels and pro forma capital ratios"

- Federal Reserve

While scope varies by institution, a common objective is to link macroeconomic factors to credit risk measures

$$\%\Delta Factor = \alpha + \sum_i [\beta_i \times \%\Delta X_i] + \varepsilon$$

Independent "explanatory" variables (macroeconomic factors)

Dependent variables (credit risk measures, such as PD)

HISTORICAL DATA

Δ in Probability of Default	Δ in 10-yr Treasury Yield	Δ in Corporate Tax Rate	Δ in 1-year Fed Funds Target	Δ in Core Goods CPI	Δ in Wages and Salaries	Δ in Consumer Confidence	Δ in Spec Grade Spreads	Δ in Non-Farm Biz Productivity	Others …
▪	●	●	●	●	●	●	●	●	●
▪	●	●	●	●	●	●	●	●	●
▪	●	●	●	●	●	●	●	●	●
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▪	●	●	●	●	●	●	●	●	●
---	…	…	…	…	…	…	…	…	…

Regression modeled

PREDICTIONS (Via regression model)

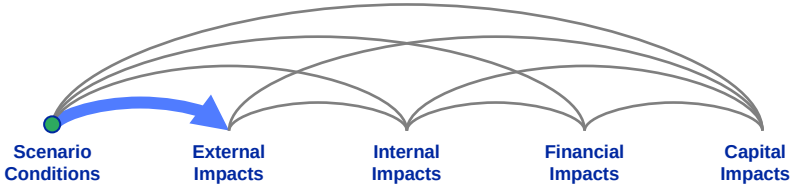
Scenario	Δ in Expected Loss	Δ in 10-yr Treasury Yield	Δ in 1-year Fed Funds Target	Δ in Core Goods CPI	Δ in Consumer Confidence	Δ in Spec Grade Spreads	Δ in Non-Farm Biz Productivity	Others …
[illegible]	?	O	O	O	O	O	O	O
[illegible]	?	O	O	O	O	O	O	O
S3	?	O	O	O	O	O	O	O
S4	?	O	O	O	O	O	O	O
S5	?	O	O	O	O	O	O	O

FOR ILLUSTRATION

Predictions

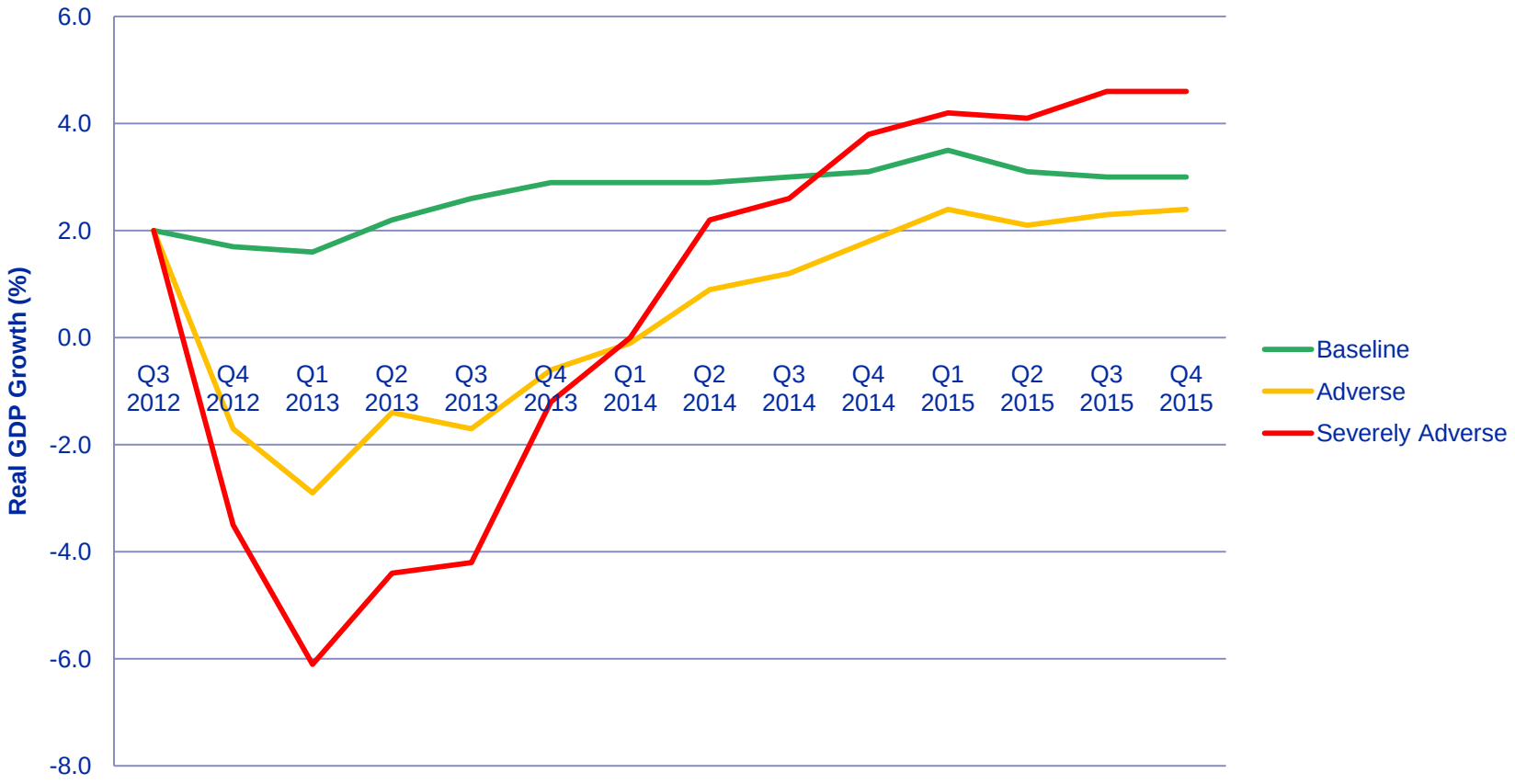
Values of macro factors from forecast scenarios

- **The macroeconomic variables are often drawn from those specified by the Federal Reserve in the CCAR process but the final set are jointly determined**
- **Banks and the Fed alike use PD, LGD, and EAD models are used to calculate the EL – and translate those to charge-offs at the segment level**
- **The PD for a C&I loan is projected over the planning horizon by first calculating the PD at the beginning and projecting it forward**
- **The output can also be used to calculate rating migrations, trends in credit quality, and influencing portfolio decisions**

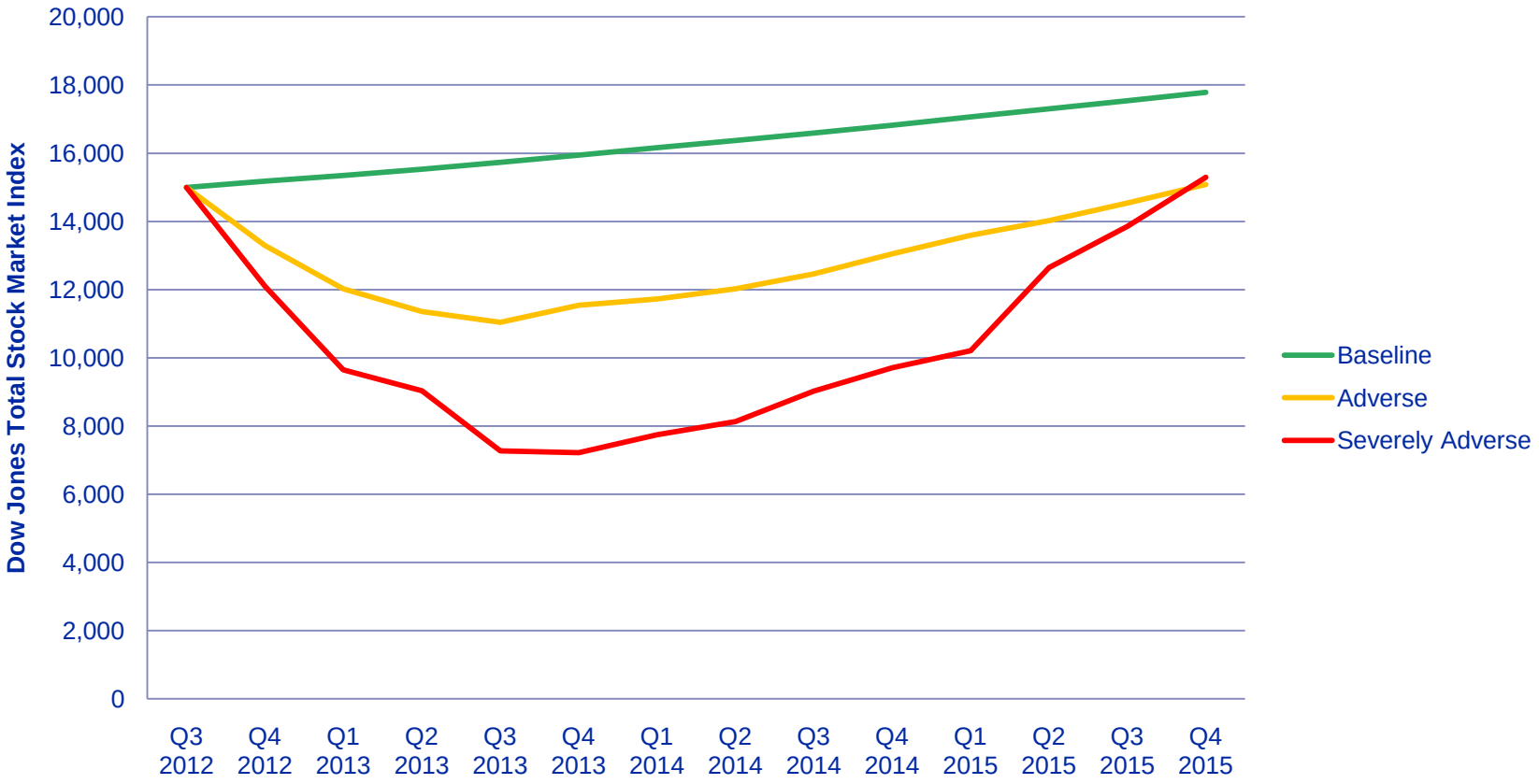


Our goal is to translate the relationship between scenario conditions and their impact

Federal Reserve Supervisory Scenarios 2012 (Real GDP)



Federal Reserve Supervisory Scenarios 2012 (DJIA)



Recent representative engagements in the US

Stress Testing Engagements (where RiskCalc was included)

1

Regional Bank

- Development of a stress testing framework for C&I portfolio
- Stressed at the ratio-level (i.e., stressed financial statement items)
- Used RiskCalc v3.1 US (and v4.0 Corporate) as primary engine for generating stressed NCOs

2

CCAR Bank

- Development of challenger models following Fed methodology described in the CCAR disclosures
- C&I loan portfolio
- PD, LGD, EAD framework
- Use of Moody's analytical resources and data

3

CCAR Bank

- Development of a stress testing framework for a wholesale portfolio of a top 5 U.S. bank
- Creation of challenger models using Moody's data and analytical resources
- Development of primary models using combined Moody's and client datasets
- Support through model validation, regulatory review

2

RiskCalc Plus and stress testing for private C&I portfolios

Mehna Raissi, Director, RiskCalc Product Management

RiskCalc: Credit Research Database (CRD)

The largest financial statement and default database in the world

12 Million Unique Private Firms → **50 Million Financial Statements** → **800,000 Defaults Worldwide**

Country	Last Updated	Borrowers	Defaults	Default Range	Statements	Statement Range	Default Statement Range
South Africa	5-2012	65,408	1,813	1989-2010	214,346	1983-2011	1989-2011
Africa		**65,408**	**1,813**		**214,346**		
Australia	1-2007	33,551	2,856	1987-2006	115,069	1980-2006	1980-2006
China	11-2012	580,789	-	-	1,275,664	2000-2010	-
India	12-2011	11,798	-	-	43,527	1990-2011	-
Japan	4-2013	320,164	25,503	1990-2012	1,762,130	1982-2012	1983-2012
Malaysia	6-2012	16,666	222	2002-2011	58,259	1930-2012	1999-2010
Singapore	2-2013	3,771	61	2003-2010	21,618	1999-2011	1999-2010
South Korea	2-2007	145,237	25,883	1982-2005	541,388	1994-2005	1994-2005
Asia Pacific		**1,111,976**	**54,525**		**3,817,655**		
Austria	11-2012	67,854	7,859	1980-2012	240,900	1989-2011	1989-2011
Belgium	12/1/2012	513,718	62,616	1951-2012	4,334,695	1991-2012	1991-2012
Denmark	4-2010	192,748	13,632	1996-2010	892,900	1996-2009	1996-2009
Finland	3-2010	43,595	3,481	1994-2010	214,711	1996-2009	1996-2009
France	2-2013	1,918,253	115,481	1988-2012	11,030,944	1989-2012	1990-2012
Germany	3-2013	279,057	9,602	1995-2012	935,583	1987-2012	1987-2011
Italy	1-2013	581,747	23,599	1992-2010	2,548,810	1990-2011	1990-2010
Netherlands	3-2013	1,393,389	37,679	1901-2012	4,244,478	1990-2012	1990-2012
Norway	12-2012	207,513	34,543	1920-2012	1,472,532	1994-2010	1994-2010
Portugal	2-2013	87,348	3,255	1993-2012	353,447	1993-2011	1993-2011
Russia	4-2013	1,467,444	131,782	2001-2012	5,215,006	1999-2012	1999-2012
Spain	11-2012	649,571	26,448	1987-2012	3,089,098	1987-2011	1991-2011
Sweden	10-2010	231,800	74,039	1988-2010	1,816,414	1992-2009	1992-2009
Switzerland	4-2009	37,845	4,495	1996-2008	227,737	1996-2008	1996-2008
Ukraine	12/1/2012	418,009	24,816	1997-2011	1,791,839	1999-2010	1999-2010
United Kingdom	11-2012	2,350,079	130,881	1959-2012	6,492,735	1980-2012	1980-2012
Europe		**10,439,970**	**704,208**		**44,901,829**		
Brazil	12-2011	11,938	-	-	37,124	1993-2011	-
Canada	1-2013	37,080	3,413	1997-2012	227,836	1988-2012	1991-2012
Mexico	6-2008	5,730	1,882	1994-2005	17,455	1980-2007	1980-2007
United States	1-2013	281,926	50,624	1980-2012	1,615,690	1980-2012	1981-2012
Americas		**336,674**	**55,919**		**1,898,105**		
World		**11,954,028**	**816,465**		**50,831,935**		

Data as of 05/01/13

RiskCalc Plus's Global Presence: Network of 29 World-Class Models

The RiskCalc Plus network is comprised of unique models covering:

Americas: USA, Canada and Mexico country models, plus U.S. Insurance, U.S. Banks and North America Large Firm

Europe, Middle East and Africa: Austria, France, Netherlands, Nordic (Denmark, Norway, Sweden, Finland), Portugal, Spain, UK, Germany, Belgium, Italy, South Africa, Switzerland, Russia, Banks

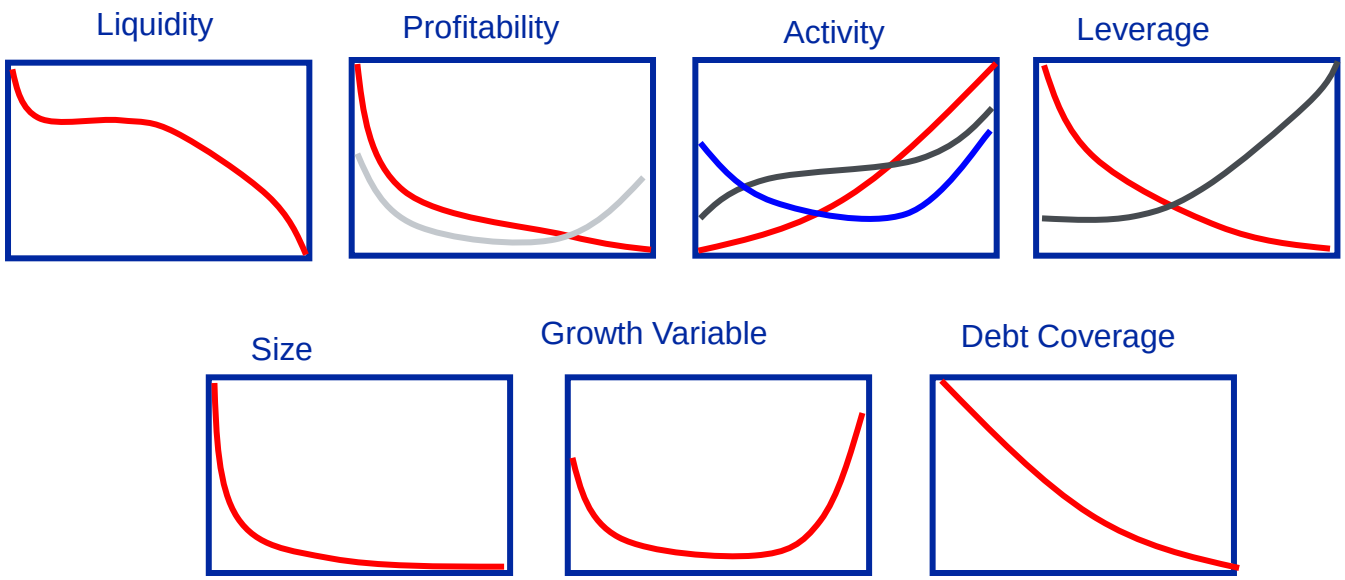
Asia Pacific: Japan, Korea, Australia, Singapore, China, Banks

Other: Emerging Markets

RiskCalc™ Modeling Process

1. Collect Financials and Default Data
2. Select Relevant Ratios
3. Compute the Model Output
4. Calibrate the Model Output to Actual Defaults: Financial Statement Only EDF™ (Expected Default Frequency)
5. Incorporate a market signal to determine the Credit Cycle Adjusted EDF

Identifying the Relevant Ratios to Estimate Default



We first identify broad categories of ratios relevant to default.

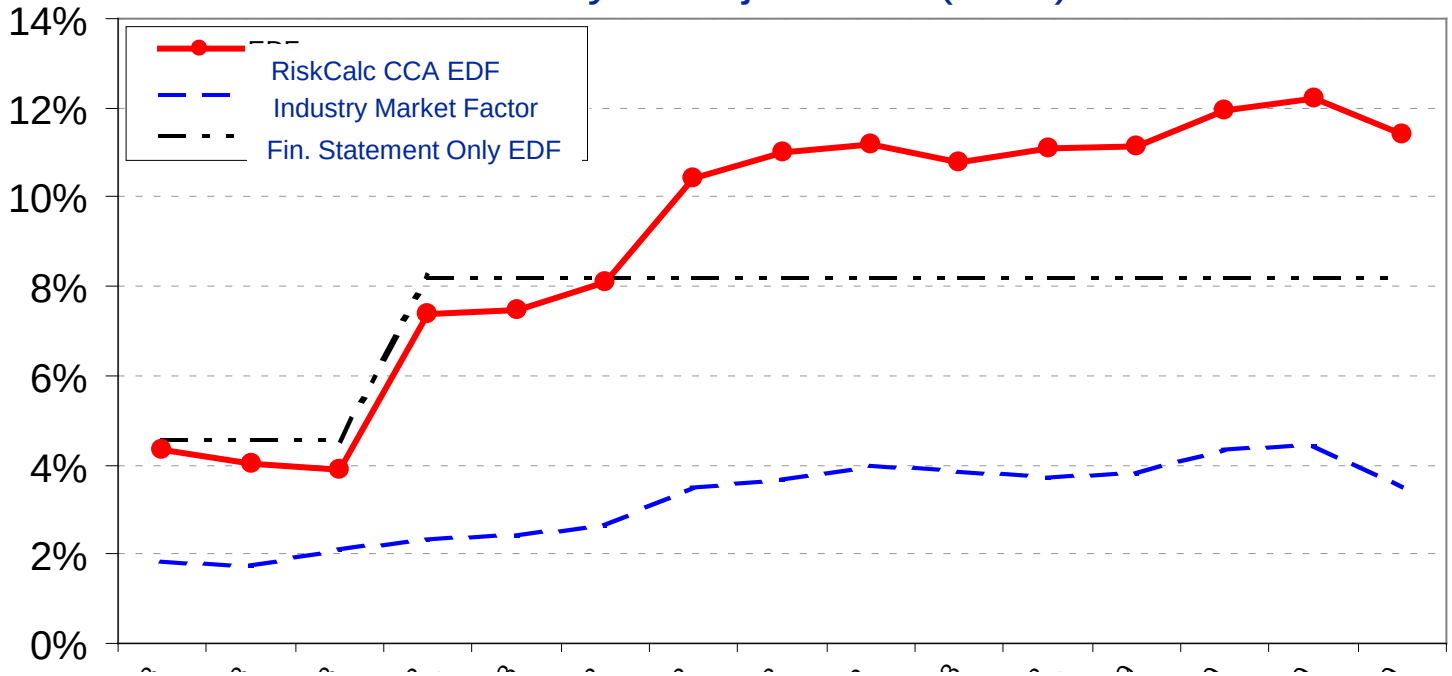
Within each category, we then select ratios with:

- High predictive power
- Data availability
- Intuitive behavior

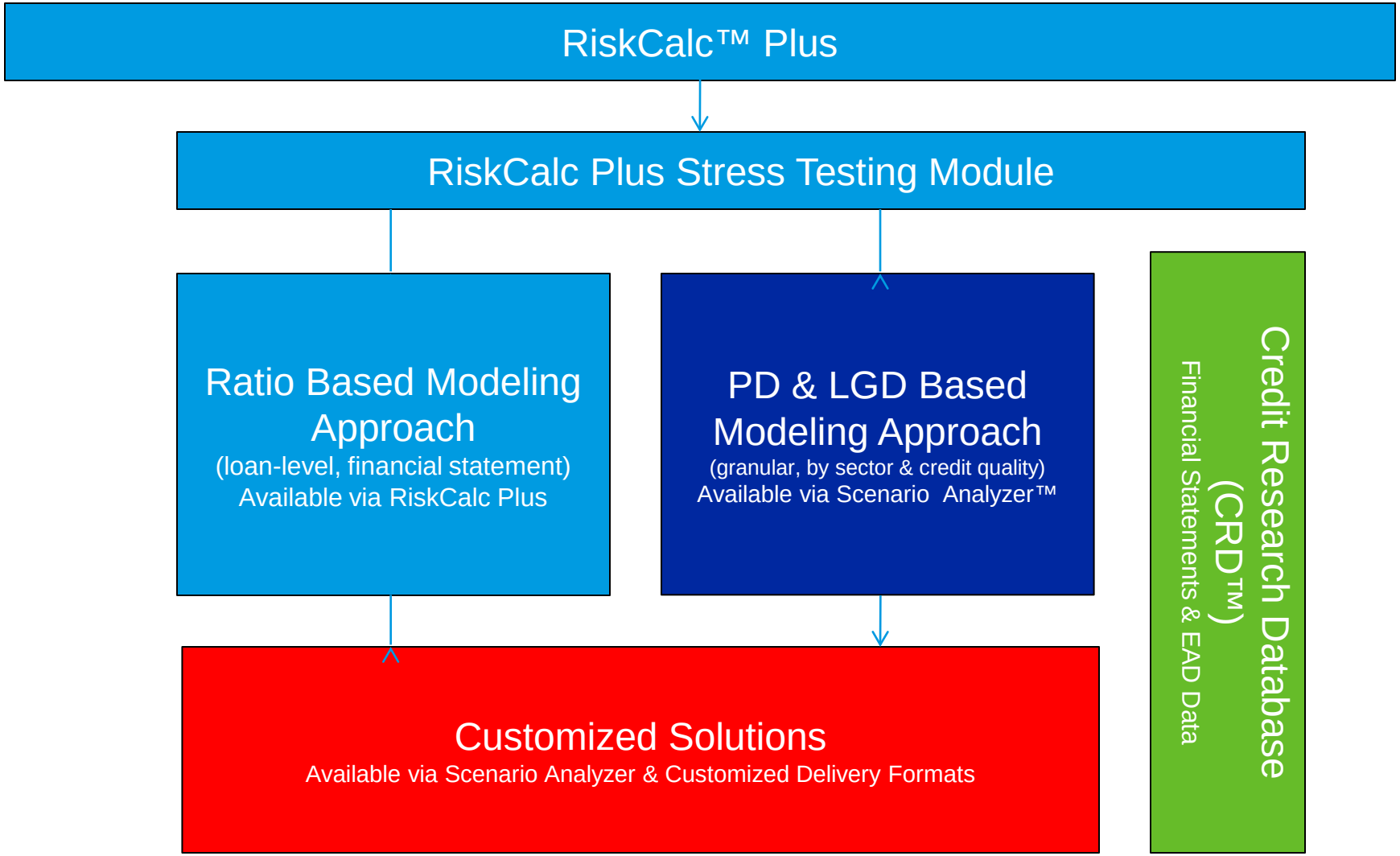
Update the Risk Assessment Without New Financial Statement Information

The Impact of Industry Market Information

Credit Cycle Adjustment (CCA)



RiskCalc Plus Stress Testing Offerings



What's the difference between the two modeling approaches?

RiskCalc Ratio Based Approach
(Obligor-Level Modeling)

» **Access:**
- Via RiskCalc Plus website single and batch

» **Data**:
- Credit Research Database (CRD)

» **Inputs:**
- RiskCalc US 4.0 Corporate Income Statement & Balance Sheet Inputs
- Macro Scenarios

» **Modeling**:
- Financial ratios are linked to macroeconomic variables
- CCA "credit cycle adjusted" view for forecasted EDFs under stressed scenarios

» **Output**:
- Two years of pro-forma financials
- Baseline EDF and Stressed

RiskCalc PD&LGD Based Approach
(Granular Modeling)

» **Access:**
- Via Scenario Analyzer or Custom Delivery

» **Data**:
- Credit Research Database (CRD)
- Default & Recovery Database (DRD)

» **Inputs:**
- Initial PD (from internal ratings or model)
- Sector
- Debt type (secured loans and unsecured loans)
- Macro Scenario

» **Modeling**:

» Calibrated on RiskCalc US 4.0
- PD: Forecasting future change in PD based on PD level, sector and forecasted macro scenarios
- LGD: Predict recovery rates based on debt type, sector, stressed PD levels and macro scenarios

» **Output**:
- Segment-level stressed PD & LGD, Expected Loss, Charge Offs

3

Stress testing models for your private C&I portfolio

Douglas Dwyer, Managing Director – RiskCalc Research

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Stress Testing with RiskCalc
PD&LGD and A Ratio Based Approach

1

Overview

Stressed PDs can be computed with different degrees of granularity in RiskCalc

The PDs of private firms change due to changes in both the financial statements and changes in the credit cycle adjustment

When the economy goes into a recession

- The financial statements of private firms get worse
- The cyclical risk of private firms increases as measured by the Credit Cycle Adjustment in RiskCalc

One can stress the PD and LGD of a rating bucket/sector combination (PD/LGD)

- More top-down

Alternatively, one can start at the financial statement level (bottom-up)

- One can estimate the impact of the adverse business environment on the financial statements
- Further model the Credit Cycle Adjustment factor

2.1 PD & LGD

Overview

- A model with the following features
  - Similar to Fed's CCAR model

    "... estimation of a series of equations relating historical changes in the median PD for 12 different borrower industries, six credit quality categories, and countries of incorporation to macroeconomic variables, including changes in stock price volatility and the spread on BBB-rated corporate bonds ..."-- Comprehensive Capital Analysis and Review 2012: Methodology and Results for Stress Scenario Projections

  - Generic: can be applied to any portfolio with initial PD assigned ("scenario analyzer" in CE+)
  - Granularity: Different impact of macroeconomic variables for different sectors and credit qualities
  - Most important: produce reasonable stress numbers

Model Specification

Macro Variables		Credit Migration
❑ GDP ❑ Unemployment ❑ DJX, VIX ❑ Credit Spread	⟷	❑ Shift of EDF distribution ❑ Sector Effect ❑ Rating Effect

- **Dependent variable:** the shift of EDF distribution for each sector/rating **bucket.**
  - » Change of Log-median EDF: $mEDF_{t+1} - mEDF_t$

- **Main Model: Two-way Fixed Effect Model**

$$y_{s,r,t} = \rho y_{s,r,t-1} + \alpha_s + \alpha_r + \sum_{i=1}^{M} (\beta_{i,s} + \beta_{i,r}) X_{i,t+1} + \varepsilon_{s,r,t},$$

  - » *s* denotes sectors, *r* denotes ratings, *t* denotes time points.
  - » *Xs* are macroeconomic variables.
  - » Different variations of the main model: sector or rating effect only
  - » 1st lag of dependent variable: high persistency of dependent variable

PD Model Specification

$$y_{s,r,t} = \rho y_{s,r,t-1} + \alpha_s + \alpha_r + \sum_{i=1}^{M} (\beta_{i,s} + \beta_{i,r}) X_{i,t} + \varepsilon_{s,r,t}$$

Autoregressive Term

Intercept for Dummy Variables

Selected macro variables

log(median EDF(t))
- log(median EDF (t-1))

Negative effect
- Dow Jones Index

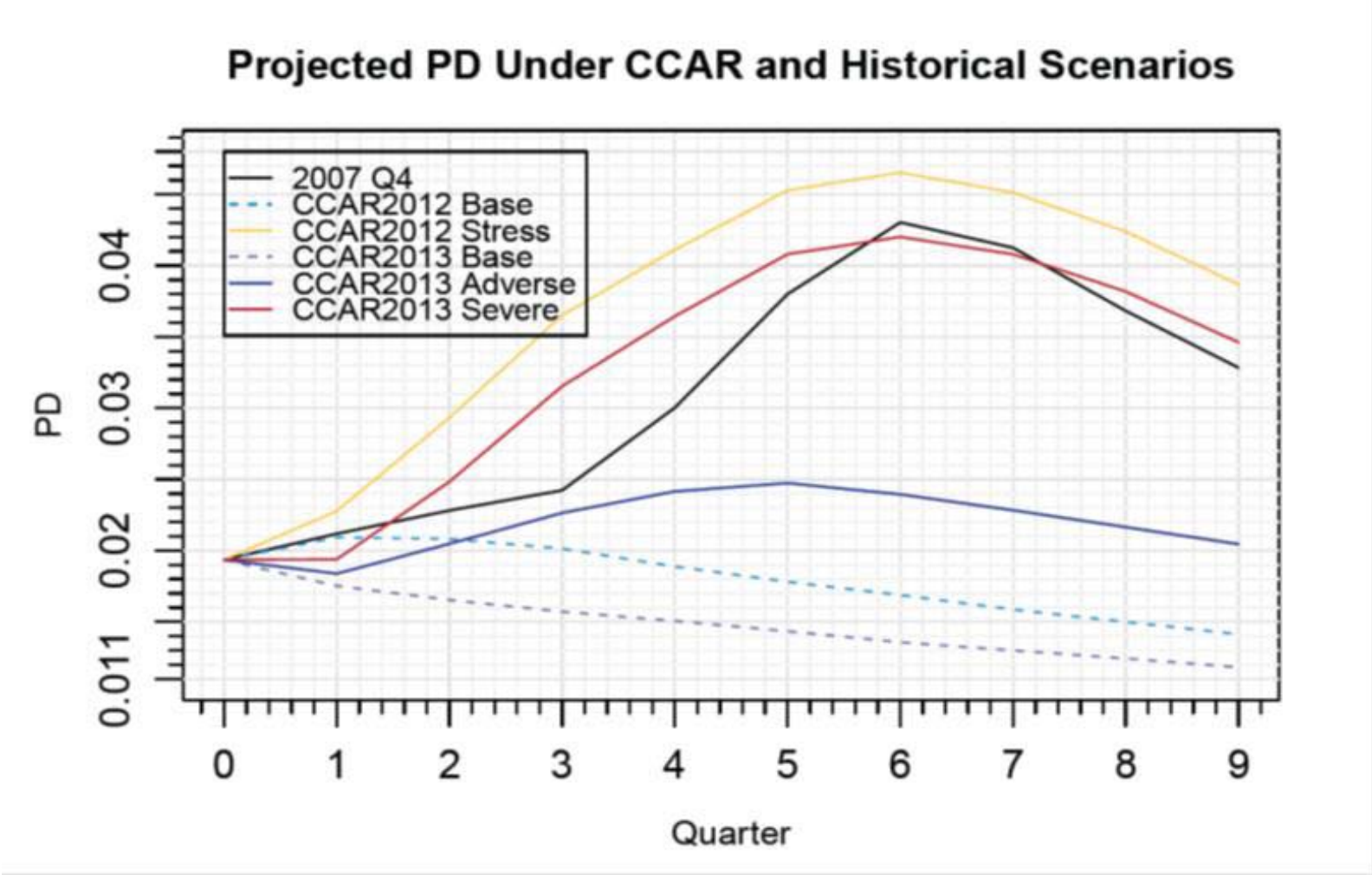
Positive effect
- Unemployment Rate
- CBOE volatility index
- Credit Spread

Analysis of Variance

Adj R-Sq 65%

Macroeconomic Variables	Transformations	Notation	Signs
Dow Jones Index	Quarter-over-quarter Growth, Lag 1	DJX_QoQ_Growth_lag1	-
Log-Credit Spread	Quarter-over-quarter change	Log_CreditSpread_QoQ_change	+
Unemployment Rate	Quarter-over-quarter change, Lag 1	Unemployment_QoQ_change_lag1	+
Log-CBOE VIX Quarterly High	Quarter-over-quarter change, Lag 1	LogVIxHigh_QoQ_change_lag1	+

Historical & CCAR 2012 & CCAR 2013



2.2 LGD Model

Moody's Default Recovery Database (DRD)

- The DRD contains information for defaulted debts. It is updated on a monthly basis and contains default events going all the way back to 1883. The data contains post-default prices from the market as well as ultimate recovery values.

- Definition of Default and Recovery
  - Default types: Bankruptcy, Chapter 11, Chapter 7, Missed principal payment, Distressed exchange and Dividend omission for preferred stocks
  - Post default price: the trading price of the default debt, expressed as a percentage of par, as of the default date for distressed exchanges or 30 days after defaults for all other types of default.
  - Ultimate recovery: the discounted value (at the defaulted instrument's effective interest rate) of these items where the bonds and the equity are marked to market using the first observable trading price

Information Used For LGD modeling

- Use data going from 1990 to 2011 Q3 and US only.
- Default
- PID (Moody's public company identifier)
- Issue rating
- Default date
- Recovery: 30-day Trading Prices with base =100
- Industry Classifications
- Debt type

Additional information:

- EDF (Moody's PD) information based on PD
- Rating-implied PD for companies without available EDF
- Industry classification to sector mapping
- Macroeconomic variables and time series

LGD Model Overview

- Start with a linear model to ensure the predicted recoveries are corrected on average. Then adjust fit in the tails to further improve the in-sample fit and bound the predicted recovery prices between 0 and 100.
- Function form:

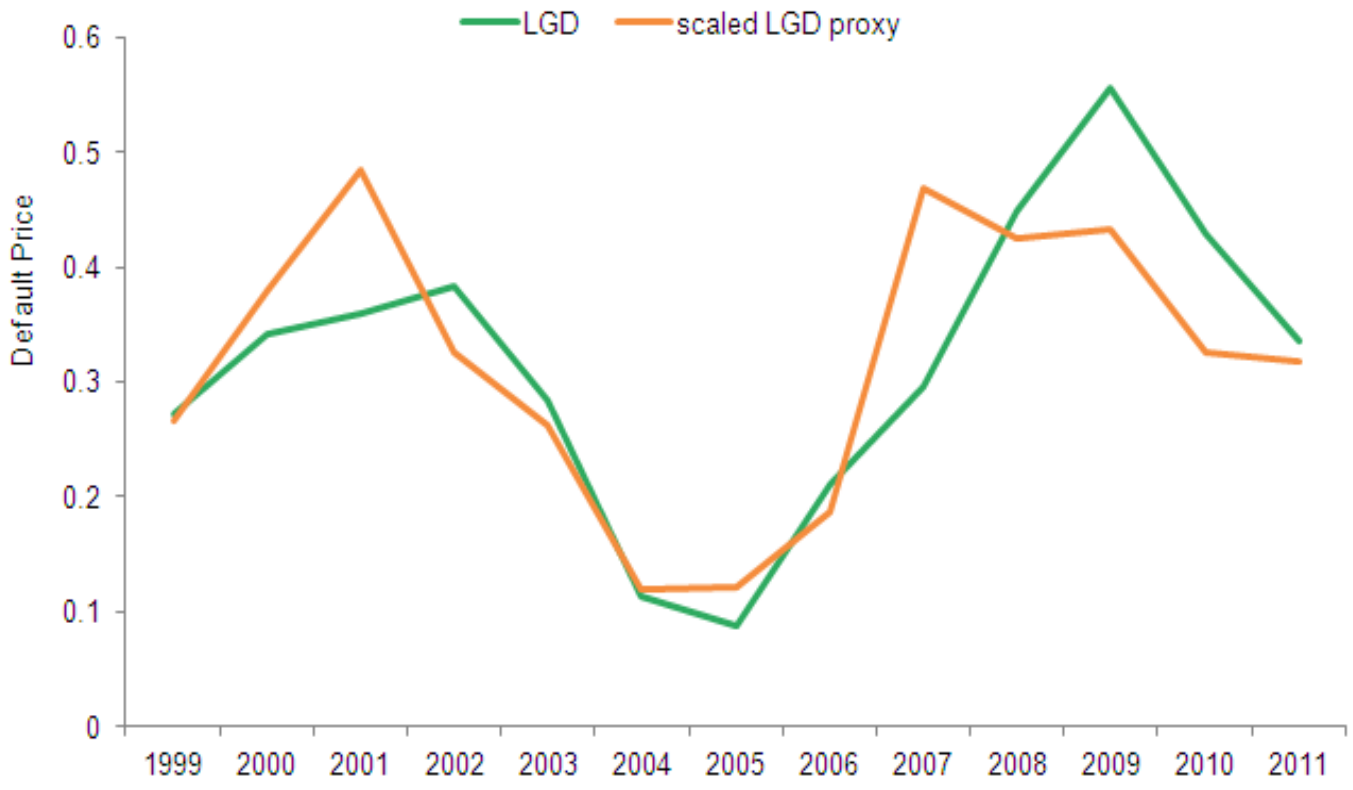
.

$$y_{i,t} = F\left(\alpha + \sum_j \beta_j \cdot DebtType_j + \sum_k \gamma_k \cdot Sector_k + \sum_m \delta_m \cdot X_m + \kappa \cdot EDF_{i,t-1}\right) + \varepsilon_{i,t}$$

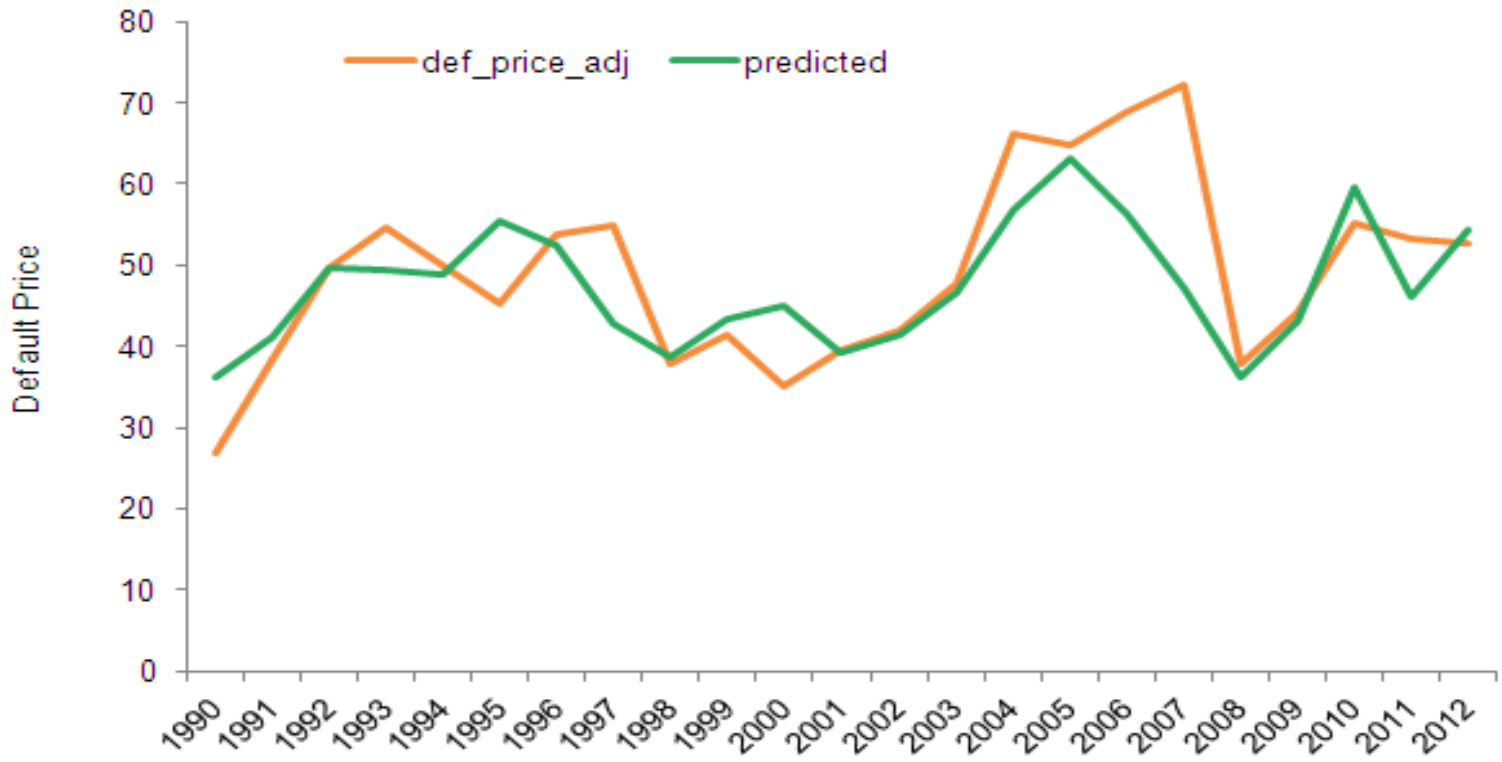
where y_(i,t) is the recovery price based on par of 100 of instrument at time t; DebtType_j is the debt type dummy; Sector_k is the sector dummy; X_m is the (transformed) CCAR macro variables ; EDF_(i,t-1) is the EDF of the instrument i one quarter prior to default. F is certain non-linear transformation.

Default Price Data Validation

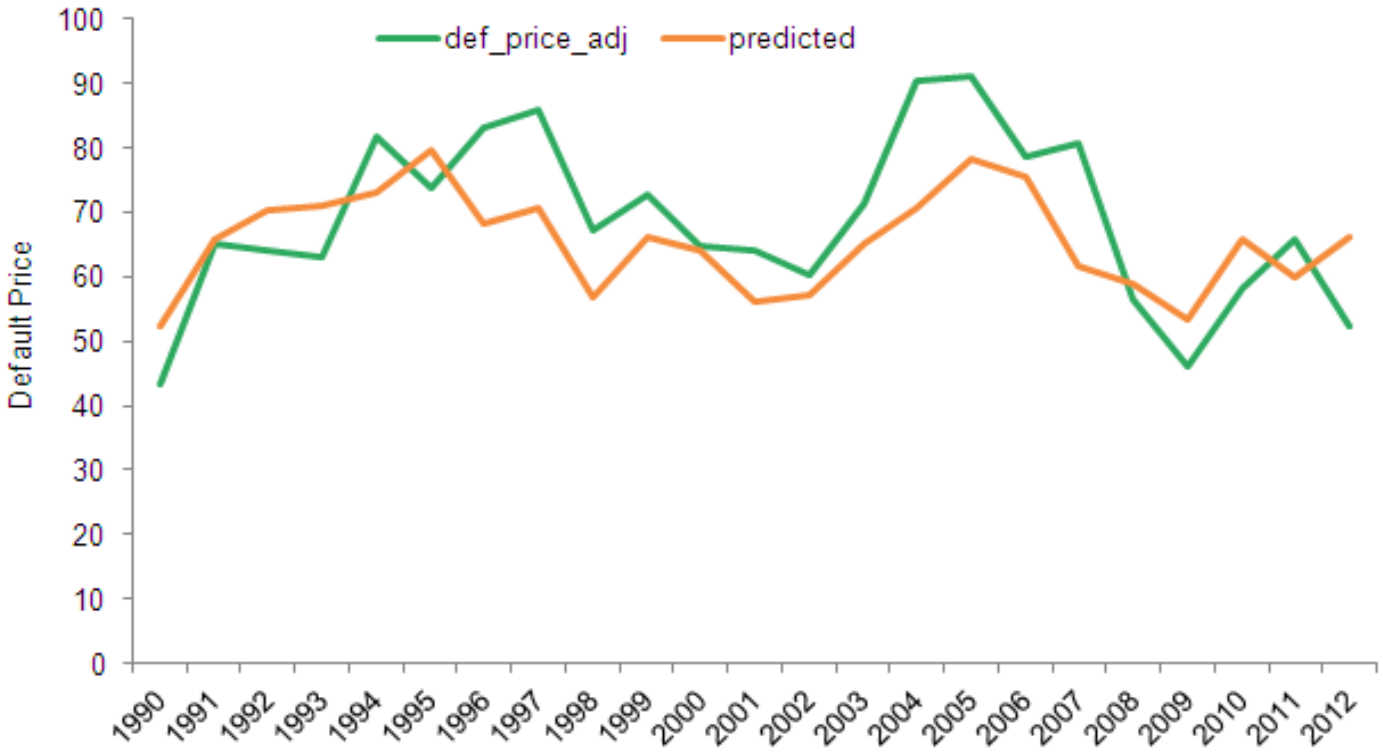
DRD data sufficiently represent of the recoveries for C&I loans of large banks . We treat the CO rate over the delinquency rate as a crude proxy for LGD (LGD~loss rate/default rate). We plot the average (100-def_price_adj)/100 and the LGD proxy from Q4 of the given year scaled to match the average DRD LGD across years



Adjusted Default Price vs. Predicted



Adjusted Default Price vs. Predicted (Loan Sample)



3

Ratio Based Approach

Ratio Based Approach

Links the key financial statement items to macro variables

Demonstrates how different balance sheet inputs behave under different hypothetical stress scenarios

Captures which types of firms are more vulnerable to a specific stress scenario

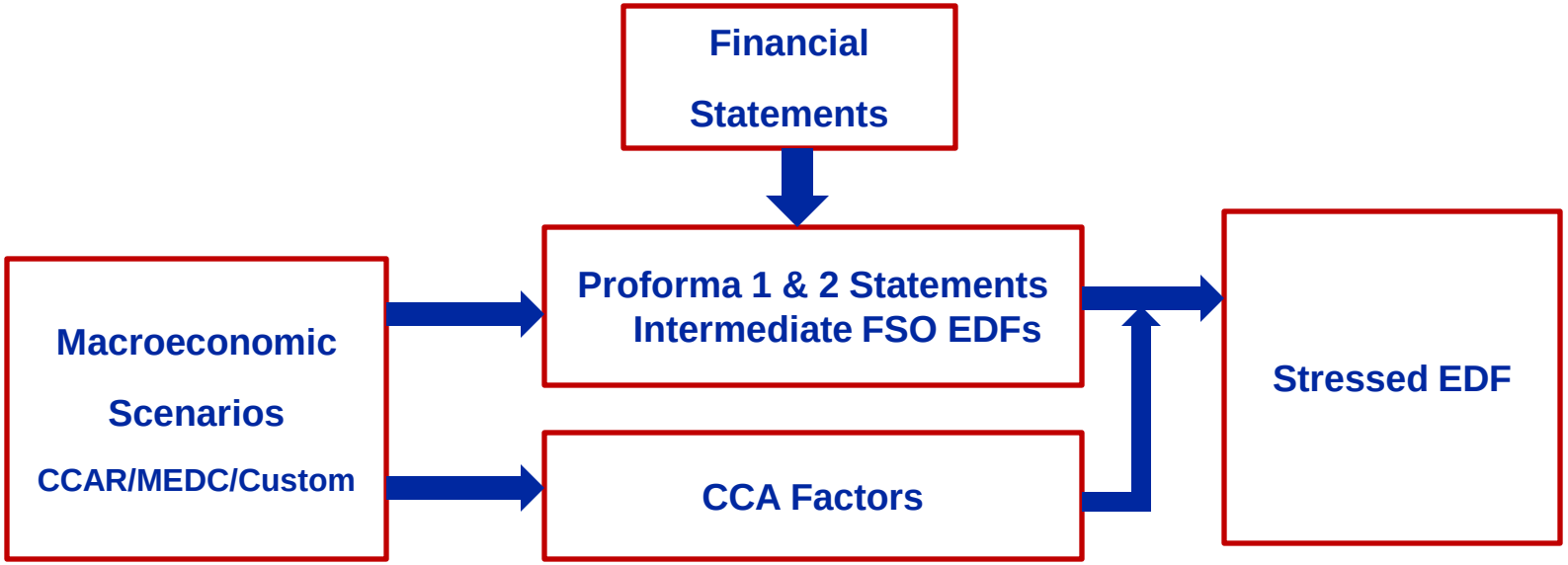
- Firms with tight margins are vulnerable to business downturns
- Firms with high leverage are vulnerable to increases in interest rates

Captures how different sectors respond to the credit cycle differently

Accommodate flexible stress testing scenarios

Good validation results both at the intermediate FSO level and at the final stressed EDF level

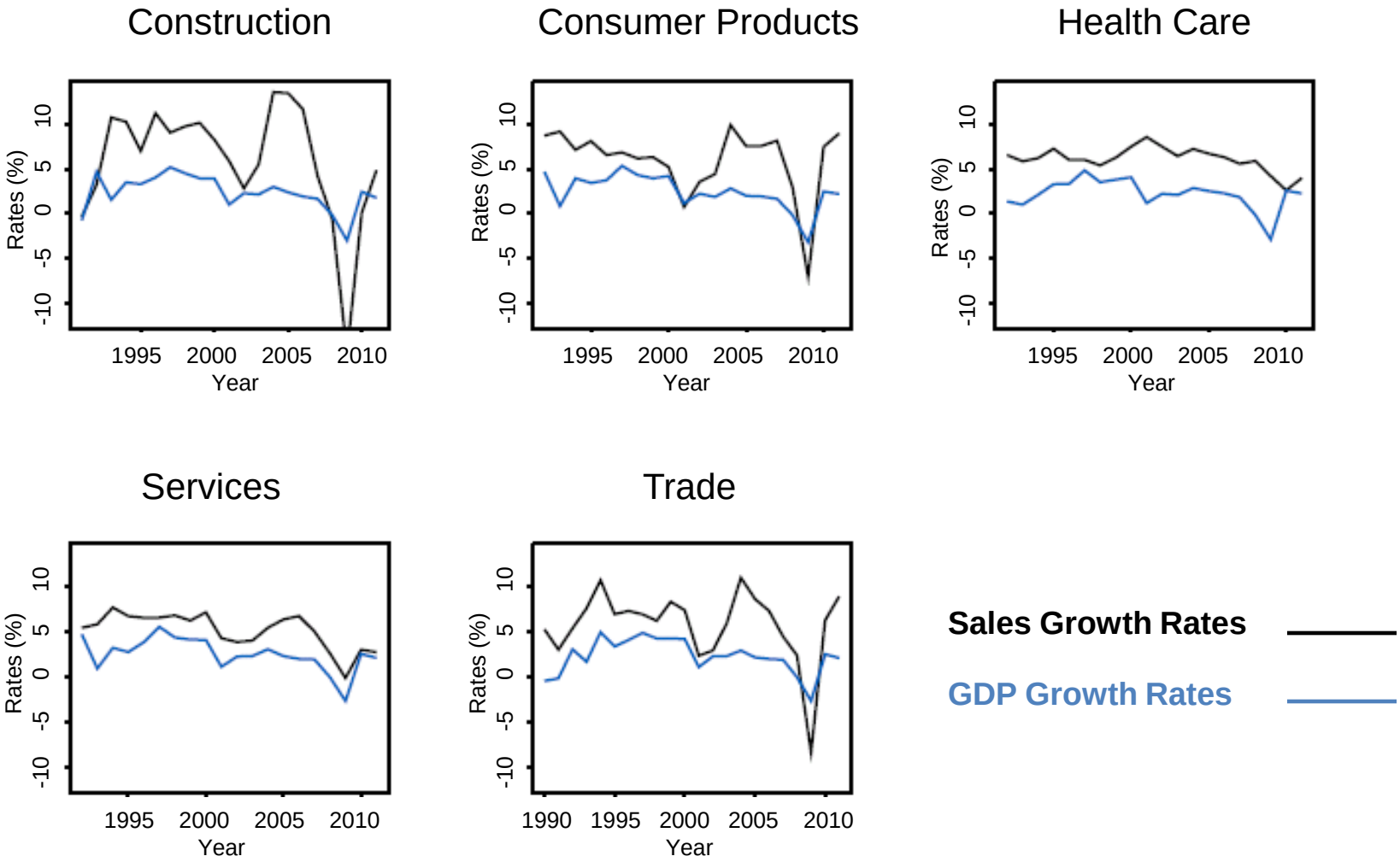
Modeling Stressed EDFs Using RiskCalc



3.1

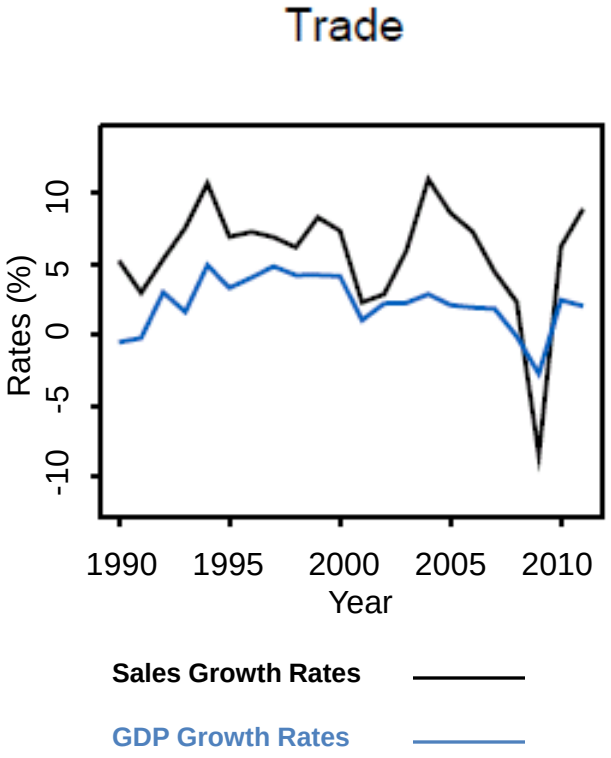
FSO Model

Different Cyclical Behavior across Sectors



We use Economic and Accounting Theory to Guide the Exercise

- During a recession, both sales and costs decline with GDP
- Interest expense increases if interest rates go up
- One can estimate the effects of the credit cycle on an income statement, which flows through to the balance sheet



A Pro-Forma Income Statement Relates Changes in Sales to Changes in Income

Variable costs such as Cost of Goods Sold move together with changes in Sales.

Fixed costs, such as Depreciation/Amortization move slowly when Sales decrease.

Sales Growth
COGS Changes
SGA Changes
Interest Expense Changes

Income Statement	
Sales/Revenue	Responds to the Cycle
-Cost of Goods Sold (COGS)	
-Selling, General and Administrative Expense (SGA)	
-Depreciation/Amortization (AMORT)	
-Other Operating Expense (OthrExp)	
Total Operating Profit	
+Financial Income	
-Interest Expenses	Responds to Interest Rates
Profit before Tax	
-Tax	
Net Income	

We Modify the Balance Sheet to Be Consistent with the Income Statement

If losses exceed cash and marketable securities:

Assets	Liability + Equity
ΔCash = -Cash$_t$ Δ LossCarryFwd = -tax*PreTaxLoss$_t$	ΔCL= -preTaxLoss – Cash$_t$
	ΔTL= -preTaxLoss - Cash$_t$
	ΔRetained Earnings = (1-tax)*preTaxLoss
ΔTotal Assets = -tax * preTaxLoss – Cash$_t$	**Δ (Liability + Equity) = -tax * preTaxLoss – Cash$_t$**

In doing the pro forma financial statements, there is discretion in the treatment of income: is it reinvested in the firm or distributed to equity holders? More conservative assumptions lead to more stressed EDFs

Note: $\Delta PreTaxNI_{t+1} = (\Delta SGR - \Delta COGs - \Delta SGA) * Sales_t - \Delta IntExp_{t+1}$
$preTaxNI_{t+1} = NI/(1\text{-}tax) + \Delta PreTaxNI$
preTaxLoss = Min(preTaxNI,0)

Model Selection Guidelines

- Clear theoretical justification
- RSQ (or *Adj.* RSQ)
- The sign and magnitude of coefficients are economically meaningful
- Significantly correlated with dependant variables

$$y_{s,t}^{g} = \alpha^{g} + \sum_{j=1}^{N} \beta_{j}^{g} X_{j,s,t} + \varepsilon_{s,t}^{g}$$

g: identifies sector group
s: identifies state
t: identifies times
X: macroeconomic variables
Y: SGR, COGS, SGA, or Interest Expense changes

One computes a Pro-Forma EDF

Starts with this year's financial statement

Computes a pro-forma financial statement using next year's macro variables that are supplied by the *scenario*.

This does not adjust for the stage of the cycle

3.2 CCA FACTOR MODEL

CCA Factor Model

$$y_{i,s,t}^{sector} = \alpha_s^{\ sector} + \sum_{j=1}^{M} \beta_{j,s}^{\ sector} X_{j,t} + \varepsilon_{i,s,t}$$

Dependent Variable: $m\left(Log_e\left(\frac{CCAEDF_t}{FSOEDF_t}\right)\right)$

Macro Variables	Effect
Unemployment rate	+
Stock Price Index	-
Market Volatility Index (VIX)	+
Spread= Baa corporate yield-10-year Treasury yield	+
Oil Price Index	+
House Price Index	-

Final variable selection

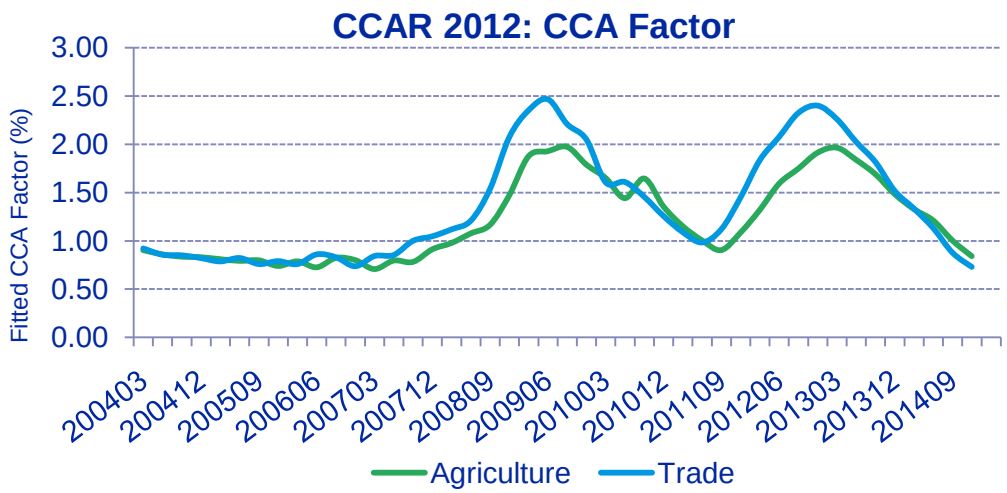
» **Selection Guidelines for Macro variables**
- Meaningful coefficient signs
- Sign stability across time periods
- Regression RSQ, AIC, BIC, t value, p value

Regression Models

Different sectors respond differently to macro-scenarios

Trade	Estimate	Std. Error*
Unemployment	0.18	0.0027***
lag(Dow Jones, 1)	-0.21	0.0205***
Log_VIX	0.27	0.0085**
R-Squared	0.80	
Adj. R-Squared	0.79	
Sample Size	3500	

Agriculture	Estimate	Std. Error*
lag(Unemployment, 1)	0.17	0.0074***
lag(Dow Jones_R, 1)	-0.17	0.0642***
lag(Log_VIX, 1)	0.21	0.0283***
lag(WTI, 2)	0.08	0.0228***
R-Squared	0.55	
Adj. R-Squared	0.54	
Sample Size	1150	



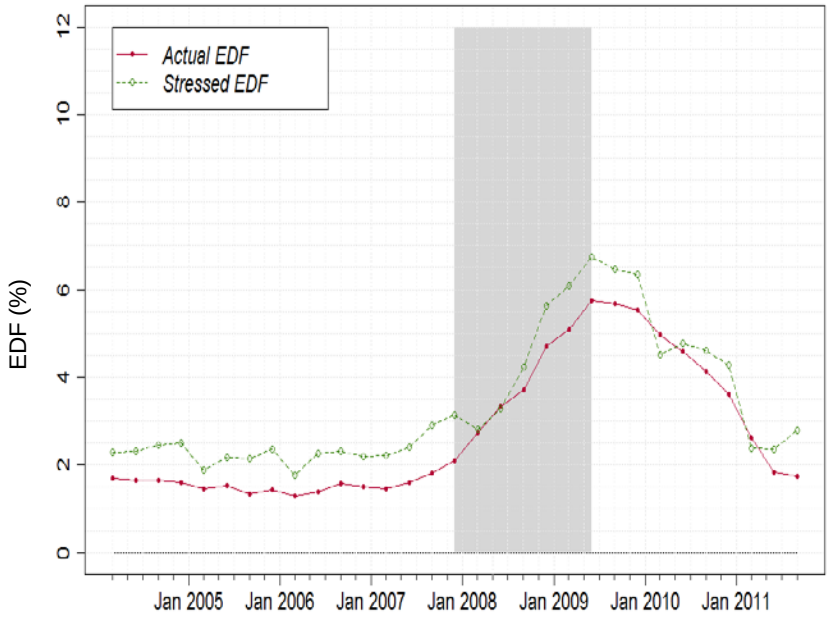
* Robust Standard Errors

4

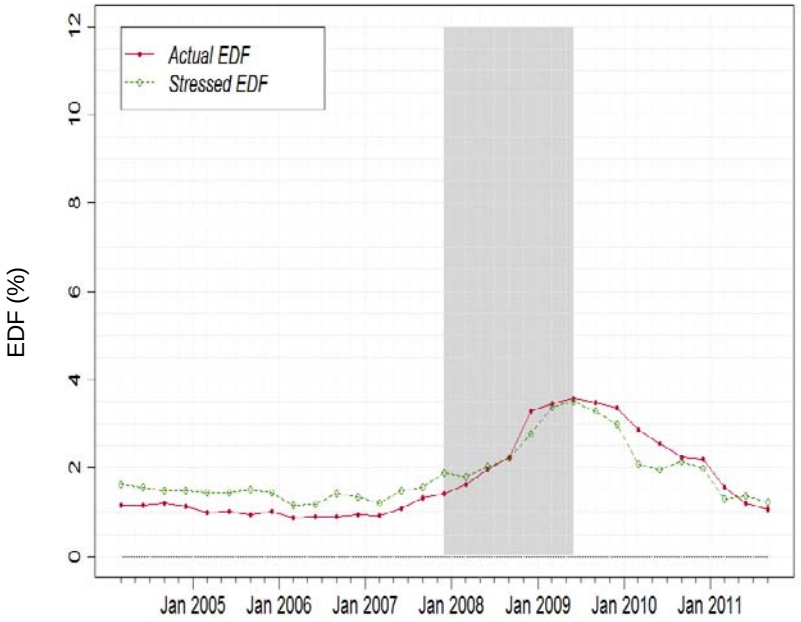
VALIDATION RESULTS

Validation: Actual vs. Stressed EDF

Trade



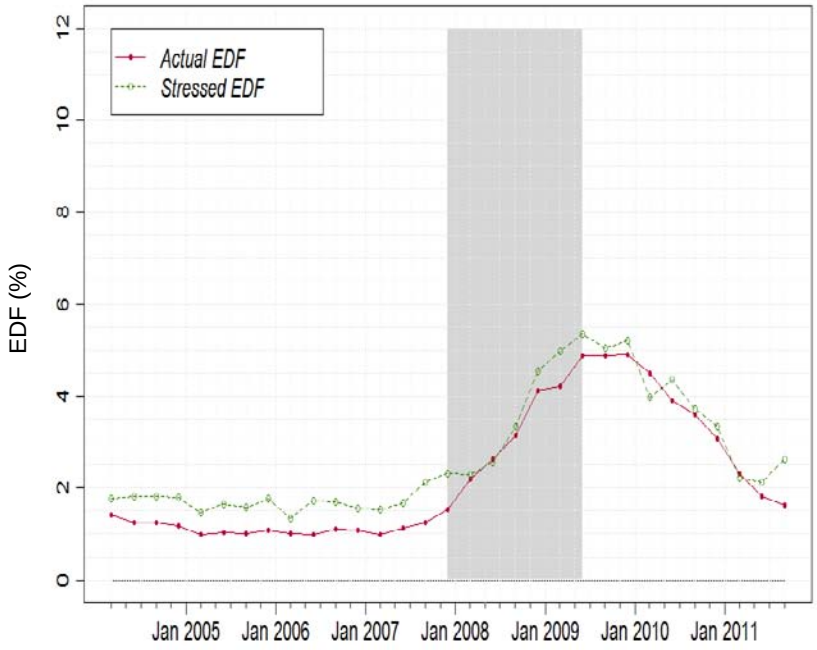
Health Care



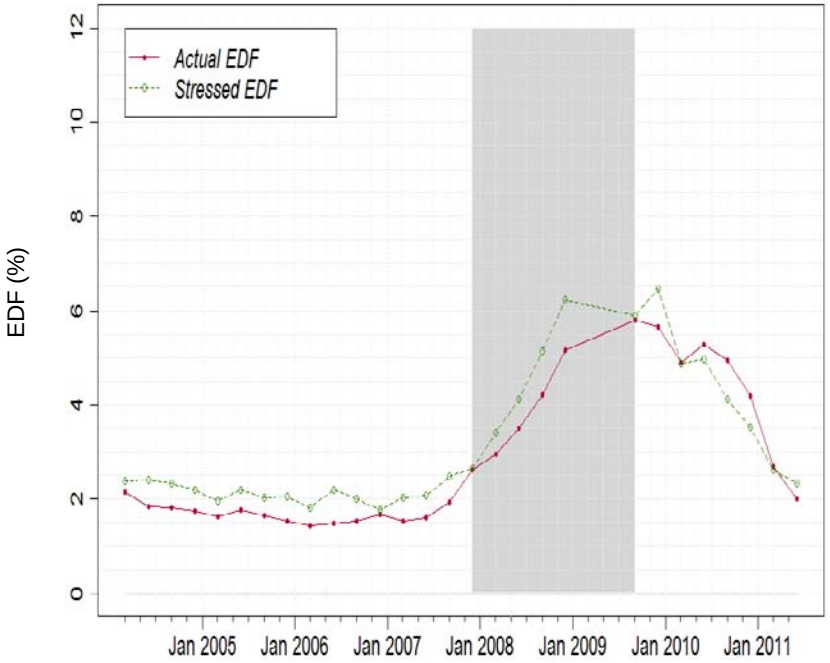
We take the financial statements of each year, get Proforma EDFs, apply the sector-specific fitted CCA factor and finally transform them to get the stressed EDF.
We average the stressed EDF and the actual CCA EDF for same set of obligors for each year month and plot them as above .

Validation: Actual vs. Stressed EDF

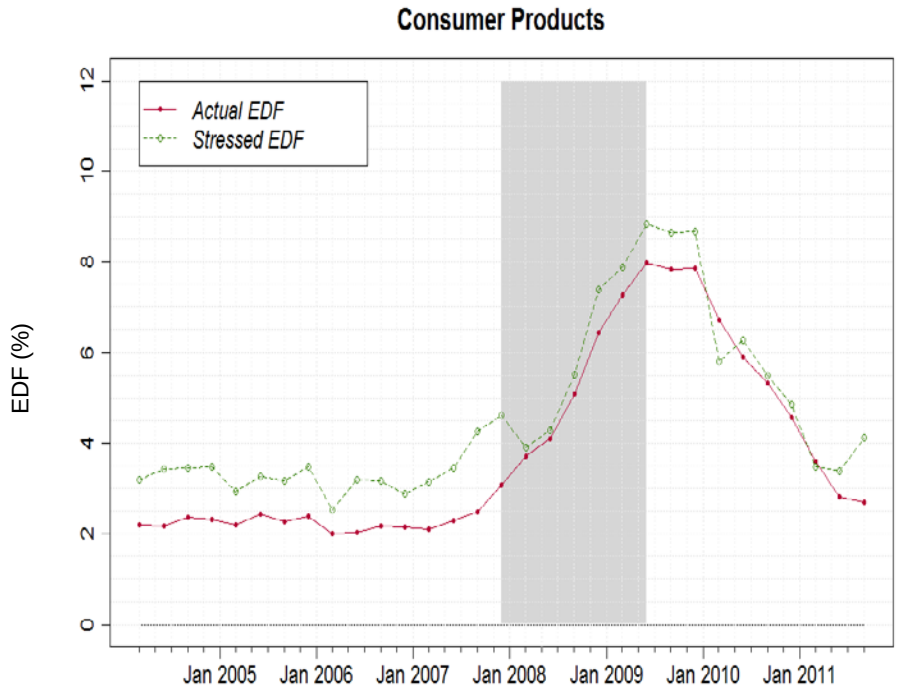
Services

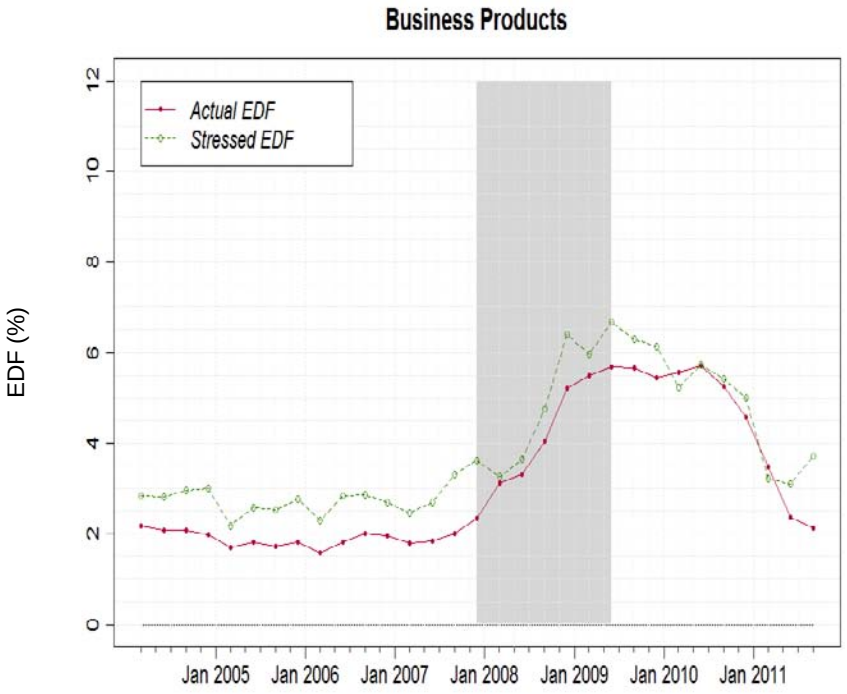


Transportation

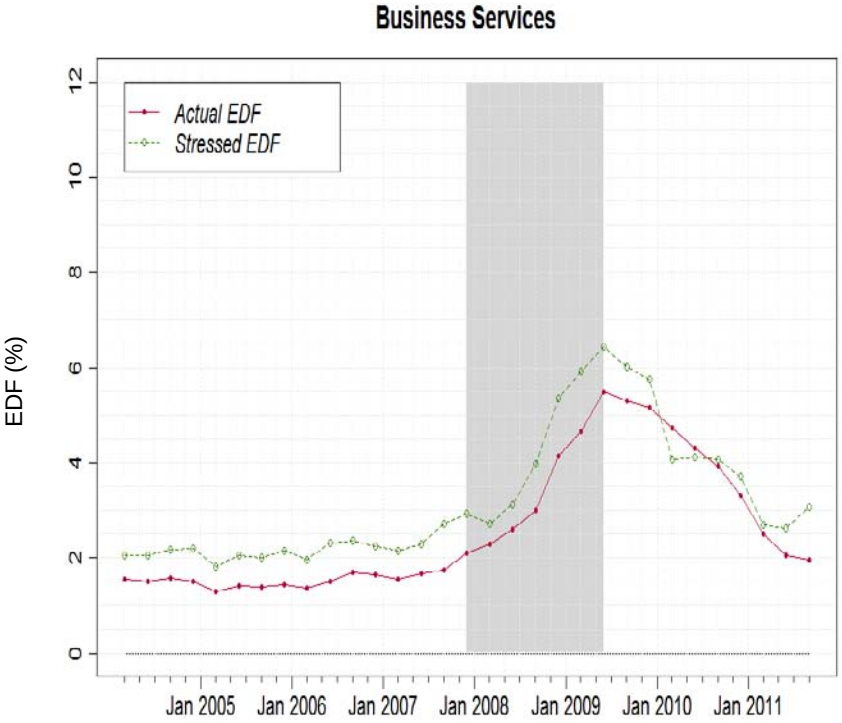


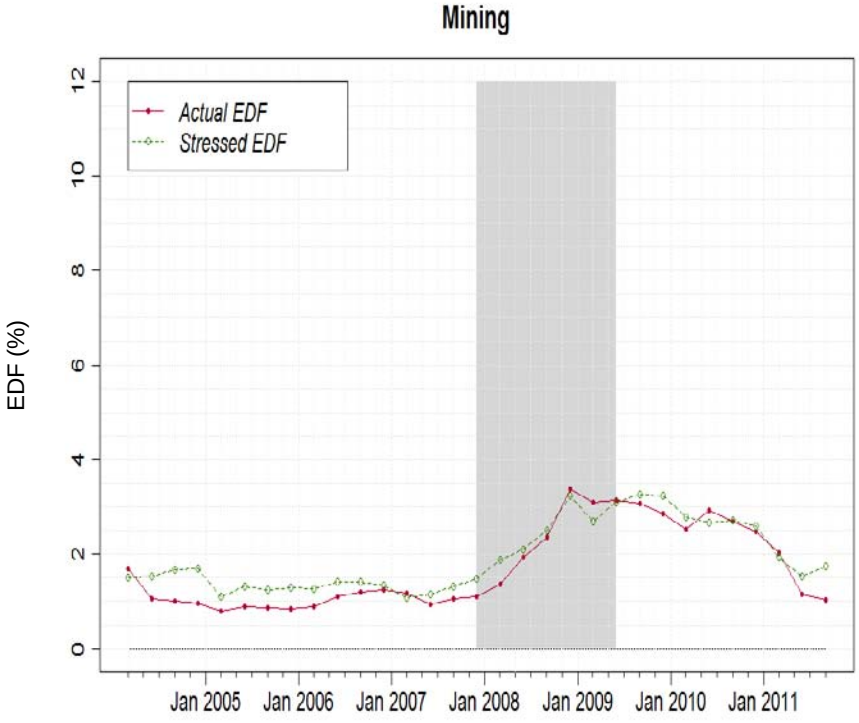
Validation: Actual vs. Stressed EDF



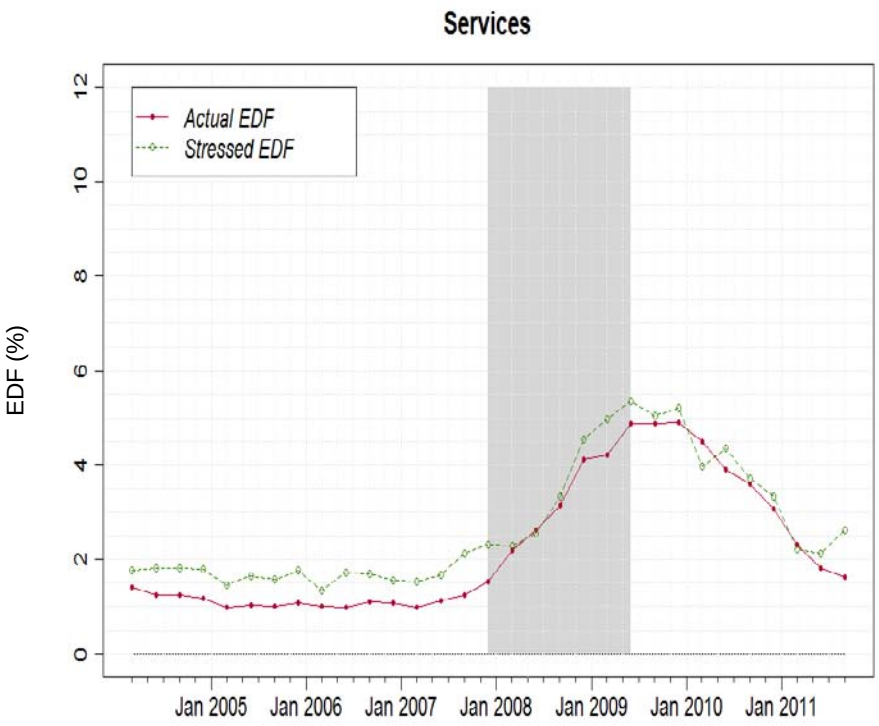


Validation: Actual vs. Stressed EDF

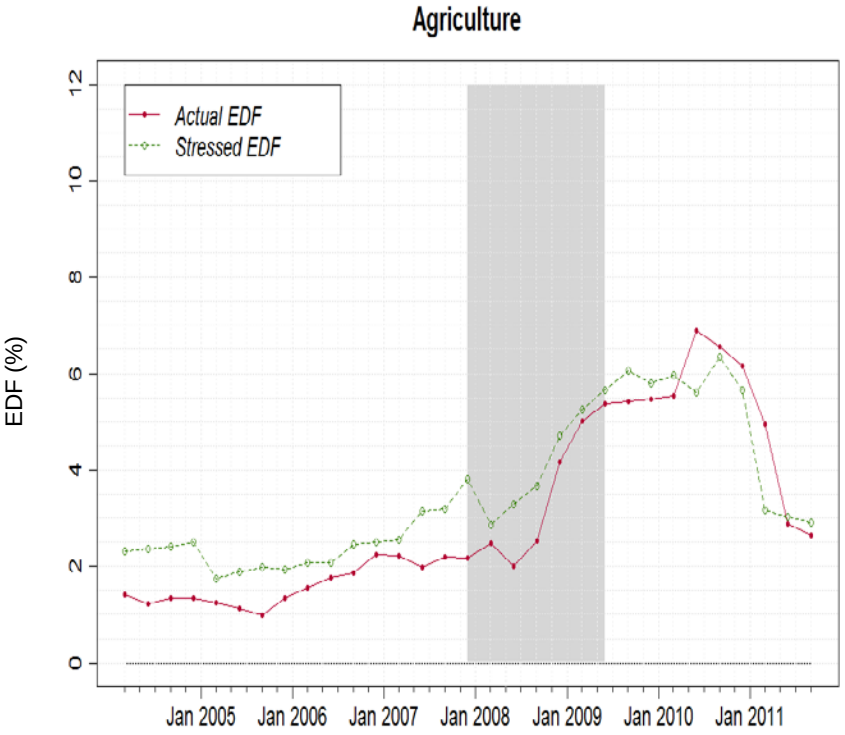


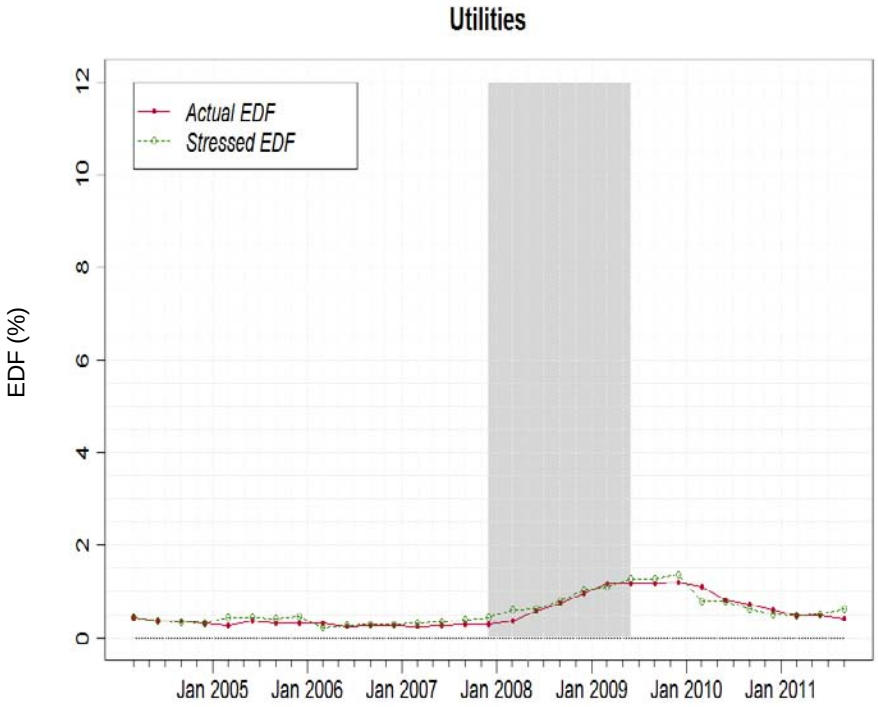


Validation: Actual vs. Stressed EDF

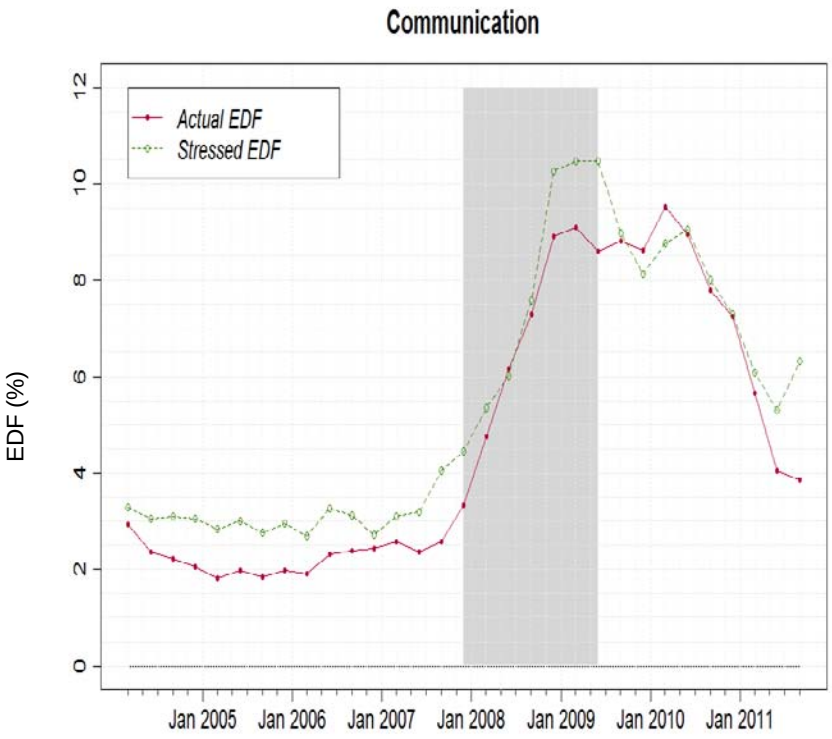


Validation: Actual vs. Stressed EDF

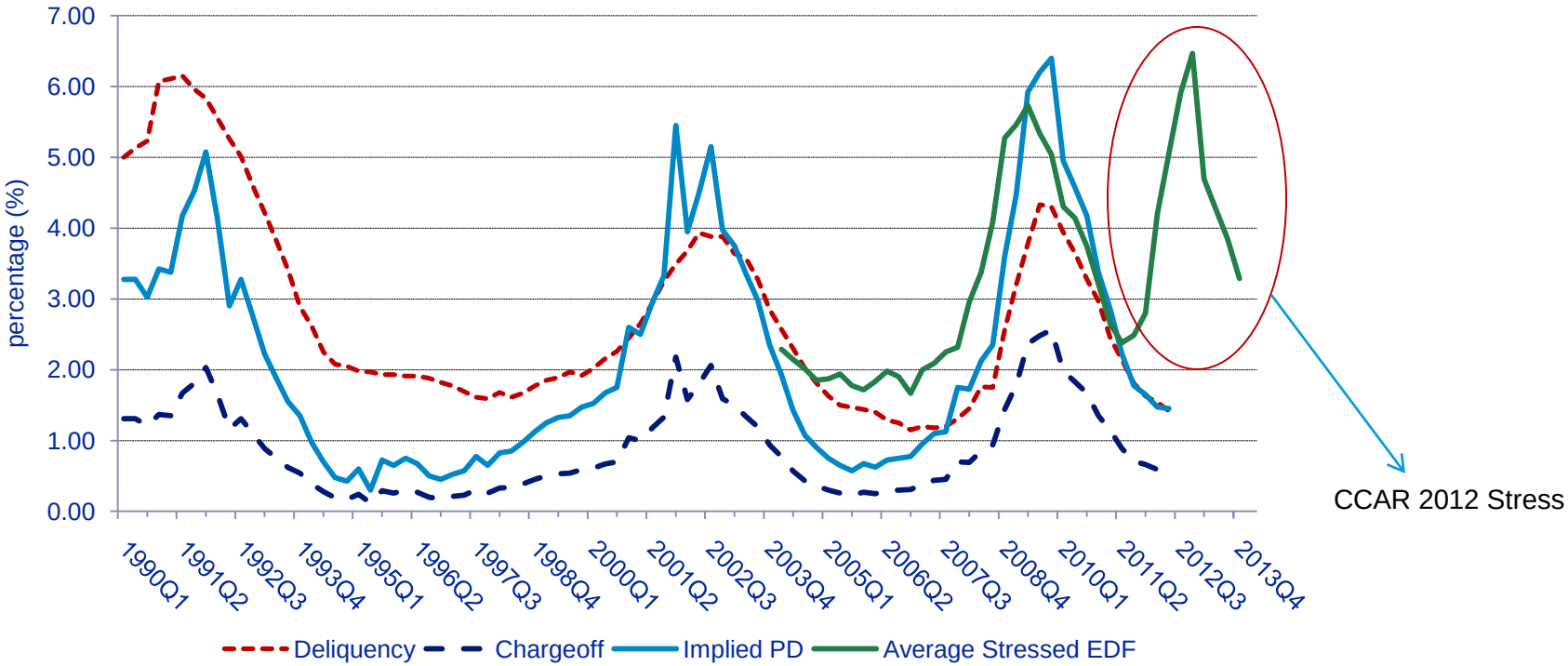




Validation: Actual vs. Stressed EDF



Bank Charge-Offs and Delinquency Rates for C&I loans



Source: http://www.federalreserve.gov/releases/
Commercial and Industrial Loans through 2012Q2
Charge-Offs implied PD (=Charge-Offs/LGD) is computed assuming an LGD of 40%

Expected Loss (2011Q4-2013Q4)= 4.05% (Predicted based on RC Stress Testing Model)

Conclusion

A top down approach stresses both PD and LGD

- Broadly applicable
- Reasonable Results

A bottom up approach based on RiskCalc Corporate model

- Link the financial statement inputs as well as CCA factors to macro variables

Validation results show that the predicted values line up well with the realized values

The model provide meaningful variations across different stress scenarios

Users can provide customized scenarios

4

Q&A

Moody's Analytics

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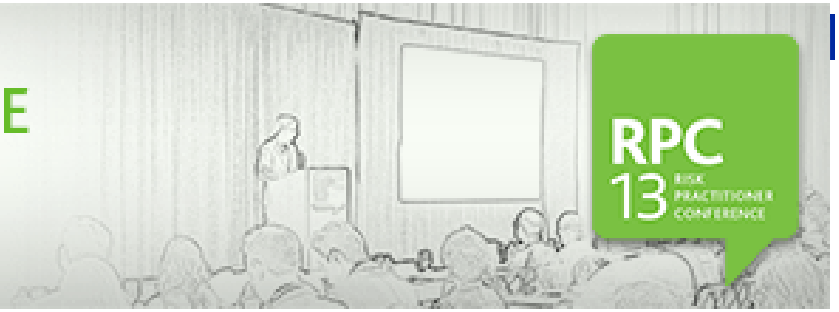

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