Capital Adequacy Stress Tests

PPNR Modeling & Scenario Development

Speakers:

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## CRISIL GR&A Summary

### Global Leader in Research & Analytics Space
- 25 year track record
- Pioneered Global Research & Analytics
- Team of more than 2,300 analysts
- Serve 12 of the top 15 global investment banks
- Serve 2 of the top 10 global consulting groups
- Serve 3 of the top 15 global insurance companies

### Regulated Entity with Strong Compliance Culture
- Regulated by SEBI, an SEC-equivalent
- The only regulated entity in this space
- Highest standards pertaining to regulatory requirements, compliance, and confidentiality

### High Quality Skill Sets
- Recognized for high quality service – Our tagline “The best people to work with” is a verbatim reproduction of what a client said in a survey
- Highly experienced and stable management team to ensure high-touch engagement
- Large talent pool comprising MBAs/CAs/CFA/FRMs/PhDs and other university graduates

### Rigorous & Scalable Processes
- Strong project management capabilities
- Quality Assurance and Governance
- Information Security
- Robust training programmes
- Business Continuity
- Inbuilt processes and tools to enhance productivity

### Unmatched Financial Business Strength
- Well-diversified business
- Strong balance sheet and zero debt
- Market reputation and global reach
- 30% CAGR over the past 10 years
- Consistent growth across business cycles that provides stability to deliver high quality services to our clients

### Partnerships with Expert Networks
- CRISIL GR&A joined the FINCAD Alliance Program in order to leverage various FINCAD Analytics tool that meets the derivatives and fixed income needs of clients. FINCAD is the market leader for innovative derivatives solutions.

### Awards & Recognitions
- **NASSCOM® Exemplary Talent Awards: 2012 (The Talent Magnets), 2011(Skill Enhancement Initiatives)**
- **Top Green IT Enterprise Award 2012** from CIO Magazine
- **'Best Leadership Training Programme' award hosted by World HRD Congress, 2012**
- Roopa Kudva named one of the 20 most powerful women in Business by Fortune India in 2011
- Roopa Kudva named one of the 30 most powerful women in Indian business by Business Today magazine, for the third time 2009-2011
- Mumbai Corporate office - LEED certified “GREEN BUILDING” 2010
- Top Research Outsourcer for Financial Services Industry Analytics, 2006, 2007 and 2009

The best people to work with
Executive Summary

- PPNR projections have assumed critical importance since the initial Fed stress tests

- One of the most common themes for PPNR modeling improvement is integration with balance sheet and credit projections

- Bottom-up model approaches have become crucial to achieve integration and robust model specification

- Shifts in regulatory focus relating to scenario development have brought into question many existing industry practices on variable coverage and the incorporation of bank-specific/idiosyncratic risk
Agenda

- **Pre-Provision Net Revenue Modeling**
  - Regulatory Landscape
  - What is PPNR?
  - Walkthrough PPNR components
    - Balance Sheet Forecasting
    - Net Interest Income
    - Noninterest Income & Expense
  - Qualitative Adjustments to Model Output
  - Documentation of Stress Test Results

- **Scenario Development**
  - Regulatory Landscape
  - UK versus US Stress Tests
  - Expansion of Supervisory Scenarios
  - Internal Scenario Development

- **CRISIL GR&A Case Studies**
  - C&I Loan Balance Forecast Model
  - Fair Value of Loans Held-for-Sale
Pre-Provision Net Revenue – Regulatory Landscape

PPNR modeling has gained in relative importance, but remains the most difficult modeled component of enterprise stress tests

1. Before Enterprise Stress Tests
   - Budgeting and strategic planning processes
   - Reliance on expert judgment

2. Initial Stress Tests (SCAP 2009)
   - Banks must project capital based on adverse economic scenarios
   - Primary focus is credit quality

3. CCAR 2011-2014/CapPR 2011-2013
   - PPNR gains in relative importance
   - Credit quality stabilizes
   - Investor emphasis on approval of Planned Capital Actions

CRISIL GR&A believes regulators are looking for:

- Linkage between noninterest income & expense, balance sheet projections, and credit forecasts
- Emphasis on bottom-up forecast methodologies
- Divergence in budgeting / strategic planning and stress test forecast methods
- Effective documentation of methodologies and results
What is Pre-Provision Net Revenue?

*In short, it is a lot of things...*

<table>
<thead>
<tr>
<th>Net Interest Income</th>
<th>Noninterest Income</th>
<th>Noninterest Expense</th>
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<tbody>
<tr>
<td>Residential Mortgage</td>
<td>Loan Fees</td>
<td>Salaries</td>
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<tr>
<td>Commercial Real Estate</td>
<td>Syndication Fees</td>
<td>Employee Benefits</td>
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<tr>
<td>Commercial &amp; Industrial</td>
<td>MSR Valuation</td>
<td>Relocation &amp; Recruiting</td>
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<tr>
<td>International</td>
<td>Credit Card Fees</td>
<td>Deposits &amp; Interest Bearing Liabilities</td>
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<td>Other Consumer</td>
<td>Deposit Service Charges</td>
<td>OREO &amp; Collections</td>
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<td>Loans &amp; Leases</td>
<td>Balance Sheet-Related Fee Income</td>
<td>Goodwill Impairment</td>
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<td>Investment Securities</td>
<td>Additional Noninterest Income</td>
<td>FDIC Assessment</td>
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<td>Specific Operational Risk</td>
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<td>Total Earning Assets</td>
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<td>Environmental Expense</td>
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<td>Software &amp; Equipment</td>
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<td>Occupancy Expense</td>
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<td>Depreciation</td>
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<td></td>
<td></td>
<td>Operating Lease Expense</td>
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<td></td>
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<td>Other Expense</td>
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Net Interest Margin (Earning Asset Yield) - Liability Rates
Balance Sheet Projections

CRISIL GR&A sees the key challenges as:

- Modeling new originations versus loan balances
- Linkage with other stress test processes
- Liquidity stress events
- Stress testing versus budgeting process

Modeling Approach

Economic Theory

- Banks serve as credit intermediaries to businesses and households
  - Commercial credit used primarily to finance investment
  - Consumer credit used primarily to finance consumption and residential investment

Variable Selection

- Common economic variables provided in regulatory scenarios
- Additional variable needs may arise to capture aggregate demand for loanable funds and supply side effects of credit availability in stress scenarios

Modeling Techniques

- Panel Regression: Easily understood and straight-forward scenario results
- Vector Auto Regression: Stands up well in both benign and stress periods
- ARIMA: Enables modeling of nominal terms instead of growth rates by addressing non-stationarity

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Balance Sheet Projections

Net Interest Income

Noninterest Income / Expense

Qualitative Adjustments

Documentation of Results

The best people to work with
Balance Sheet Projections

Modeling of new originations preferred…

- Granular pricing assumptions commensurate with credit risk
- More defendable loan balance projections
- Explicit volume assumptions allow for direct modeling of related noninterest income items

…but remains a long-term solution

- Most banks lack historical new origination data
- Existing cash flow systems geared toward “balance targeting”
- Budgeting and strategic planning groups more accustomed to ending loan balances

<table>
<thead>
<tr>
<th>Modeled Approach</th>
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<tbody>
<tr>
<td><strong>Beginning Balance</strong>&lt;sub&gt;t0&lt;/sub&gt;</td>
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<tr>
<td><strong>New Originations</strong>&lt;sub&gt;t0&lt;/sub&gt;</td>
</tr>
<tr>
<td><strong>less:</strong> Contractual Payments&lt;sub&gt;t0&lt;/sub&gt;</td>
</tr>
<tr>
<td><strong>less:</strong> Prepayments&lt;sub&gt;t0&lt;/sub&gt;</td>
</tr>
<tr>
<td><strong>less:</strong> Credit Losses&lt;sub&gt;t0&lt;/sub&gt;</td>
</tr>
<tr>
<td><strong>plus:</strong> Change in Utilization&lt;sub&gt;t0&lt;/sub&gt;</td>
</tr>
<tr>
<td><strong>Ending Balance</strong>&lt;sub&gt;t0&lt;/sub&gt;</td>
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New Originations

- Distinct Pricing (Spread to Index)
- Pre-Provision Net Revenue
- Obligor Risk Rating
- Expected Loss, NPLs

Commensurate with

Balance Sheet Projections

Net Interest Income

Noninterest Income / Expense

Qualitative Adjustments

Documentation of Results
Net Interest Income

Modeling needs are two-fold:
1. Interpolation of yield curves and credit spreads provided in supervisory scenarios
2. Modeling of spread to index and deposit pricing beta models

Net Interest Income Calculation
- Interest rates and credit spreads applied to earning asset and interest-bearing liabilities to derive net interest income

\[
\text{Net Interest Income} = \sum (\text{Balance}_{\text{Earning Asset} i}) \times (\text{Index} + \text{Spread}) \times \left(\frac{\text{days}}{\text{interest day count}}\right) - \sum (\text{Balance}_{\text{Interest Bearing Liability} i}) \times (\text{Index} + \text{Spread}) \times \left(\frac{\text{days}}{\text{interest day count}}\right)
\]

CRISIL GR&A sees the key challenges as:
- Justifying ability to maintain a given loan spread in stress scenarios
- Granularity of portfolio segmentation
- Consistency of spread to index with assumed credit quality for new originations
Noninterest Income & Expense

CRISIL GR&A sees the key challenges as:
- Lack of correlation with macroeconomic variables
- Econometric analysis not suitable for all line items
- Linkage between balance sheet and credit forecasts
- Varying data availability for non-GAAP/IFRS information

Modeling Approach

<table>
<thead>
<tr>
<th>Economic Theory</th>
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<tbody>
<tr>
<td>Banks generate higher levels of net revenues during periods of strong economic growth through greater lending activities, fiduciary income and lower environmental expense</td>
</tr>
<tr>
<td>- Fiduciary &amp; capital markets fees correlated with business investment and market indices</td>
</tr>
<tr>
<td>- Fewer FTEs required to support lending activities during periods of weak economic growth</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Variable Selection</th>
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</thead>
<tbody>
<tr>
<td>Common economic variables provided in regulatory scenarios</td>
</tr>
<tr>
<td>Additional variables needed to capture the relationship between banking activities and economic cycles</td>
</tr>
<tr>
<td>Some components are largely balance sheet and credit driven</td>
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<table>
<thead>
<tr>
<th>Modeling Techniques</th>
</tr>
</thead>
<tbody>
<tr>
<td>Quantile Regression – Well-suited for capturing regime change during economic stress</td>
</tr>
<tr>
<td>Generalized Linear Models – Useful for noninterest expense items that display bimodal distributions</td>
</tr>
<tr>
<td>ARIMA – Enables modeling of nominal terms instead of growth rates by addressing nonstationarity</td>
</tr>
<tr>
<td>Linear Regression – Can be ideal for generating Betas as a starting point for expert judgment</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Balance Sheet Projections</th>
<th>Net Interest Income</th>
<th>Noninterest Income / Expense</th>
<th>Qualitative Adjustments</th>
<th>Documentation of Results</th>
</tr>
</thead>
</table>
Expert judgment should be used to incorporate forward-looking business intelligence and address model weaknesses and limitations.

- Strong Practice: Forecasts driven by quantitative models with expert judgment when necessary
- Weak Practice: Sole reliance on model output
- Weak Practice: Sole reliance on expert judgment

Some acceptable ways to size qualitative adjustments include:
- Out of sample backtesting and challenger models
- Confidence intervals
- Quantification of enterprise-wide sensitivity to model assumptions

Use of qualitative adjustments and associated governance framework must be abundantly documented.
Inadequate documentation was cited by the Fed as one of the most prevalent problems in PPNR submissions across all banks.

Documentation should be concise and provide relevant information for credible challenge and review:
- Clear delineation between model output and qualitative adjustments
- Logic and economic rationale for variable selection clearly explained
- Inundating regulators with information is never a good strategy

Results versus Model Development Documentation – there is a big difference

FR Y-14A reporting templates versus modeled account line structure – must reconcile the two
Scenario Development – Regulatory Landscape

Major learnings on scenario development
1. Additional variables are needed to build robust models
2. Sole reliance on macroeconomic scenarios does not adequately stress the risk profiles of all bank holding companies

These learnings are reflected in new PRA and EBA stress test design

CRISIL GR&A believes regulators are looking for:
- Greater expectations for variable selection beyond core set provided in supervisory scenarios
- Use of standard off-the-shelf scenarios not suitable for capturing bank-specific risks and vulnerabilities
- Robust risk-identification processes to feed idiosyncratic scenario development
The final shape of UK stress tests is yet to be finalized, but the proposed framework has more similarities than differences with US CCAR requirements – particularly with respect to scenario design.

Both Stress Testing Frameworks Require Two Sets of Scenarios

- **Supervisory Stress Scenarios**
  - Applied across all bank participants
  - Additional variables often required

- **Internally generated scenarios**
  - Designed individually by each bank
  - Typically result in greater capital depletion than supervisory scenarios

Risk Factors Included in Common and Internal Scenarios

- **Systemic Risk**
- **Bank-specific/Idiosyncratic risk**

\[
\text{Total Risk Exposure} = \text{Systemic Risk} + \text{Idiosyncratic Risk}
\]

- **Internally Generated Bespoke Scenarios**
Addressing Scenario Development Issues

Identification & Forecasting of Additional Variables

- Modeling the components of aggregate variables like GDP (provided in supervisory scenarios) commonly needed
- Geographic and industry-specific variables may improve model performance and also incorporate idiosyncratic risk
- Most variables can be forecast using structural and agnostic models

Univariate Models

- ARMA, ARIMA, ARCH/GARCH, Interpolation, Exponential Smoothing Models with/without seasonality
- Provide easily interpretable equations and useful for short term forecasting
- Fail to provide an explanation of the causal structure behind the evolution of a time series
- E.g. Volatility, stock price, interest rates, market illiquidity could be forecasted/filled-in using such methods

Multivariate Models

- Multiple Regression, Logit and Probit Model, VAR/VECM, Generalised Linear Model, ARIMAX, Multivariate GARCH, Copula, Factor Analysis, Dynamic Stochastic Models
- Exploit the relationship between the dependent variable and several independent variables and their lags
- Framework provides a systematic way to capture rich dynamics in multiple time series

Machine Learning Models

- Artificial Neural Networks, Support Vector Machines, Random Forests, Decision Trees, Cluster Analysis
- Used for forecasting and classification purposes primarily
- Exploits the non-linearity and nonlinear relationships among the time series, requires huge amount of data for training purposes
Case Study 1
Forecasting C&I Loan Balances

CRISIL GR&A Approach

- **Macroeconomic drivers** from the Fed’s supervisory scenarios were used to model commercial loan balances as part of the PPNR modeling process.
- **Vector Auto Regression** was the chosen methodology for its ease of use and suitability for forecasting both benign and stress scenarios.
- **Challenger Model** was also developed using supplemental macroeconomic variables to help ensure the reasonableness of the primary model output.

### Champion Model

<table>
<thead>
<tr>
<th>Independent Variables</th>
<th>Coefficient</th>
<th>T-stats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Constant</td>
<td>0.0170</td>
<td>1.50</td>
</tr>
<tr>
<td>SPREAD1</td>
<td>-0.0097</td>
<td>-2.25</td>
</tr>
<tr>
<td>US Real GDP (Lag 2)</td>
<td>0.0040</td>
<td>1.70</td>
</tr>
<tr>
<td>Dow Jones (Lag 5)</td>
<td>0.1467</td>
<td>2.44</td>
</tr>
</tbody>
</table>

Adjusted $R^2 = 0.30$

- Log-Likelihood = 102.50
- Schwarz Criteria = 3.78
- Durbin-Watson Stats = 1.91

AIC = 3.93

### Insights

- **Champion Model** output closely tracked actual C&I loan growth in a sample backtest:
  - High model fit (Mean Average Error = 0.0244)
  - Directionally correct (Hit ratio = 79%)

- **Model benchmarking** shows that the champion model has been developed with adequate variable coverage to inform C&I model coefficients that result in reasonable projections.

### C&I Loan Model

**Out of sample backtest (2008-2013)**

<table>
<thead>
<tr>
<th>Quarterly % Change</th>
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</thead>
<tbody>
<tr>
<td>(10%)</td>
</tr>
<tr>
<td>(15%)</td>
</tr>
</tbody>
</table>

Recession Dates | Actual | Champion | Challenger

Macroeconomic drivers from the Fed’s supervisory scenarios were used to model commercial loan balances as part of the PPNR modeling process.

Vector Auto Regression was the chosen methodology for its ease of use and suitability for forecasting both benign and stress scenarios.

Challenger Model was also developed using supplemental macroeconomic variables to help ensure the reasonableness of the primary model output.
Case Study 2
Fair Value of Loans Held-for-Sale (HFS)

Background

- Bank had a substantial loan warehouse subject to fair value accounting
- Top-down approach was previously used by modeling dollar losses on the loan warehouse

Client Impact

- Significantly reduced market risk-related losses by separately taking into account underlying exposure and credit spread indices (i.e., bottoms-up approach)

CRISIL GR&A Approach

- Macro-to-micro model was developed to forecast credit index spreads widely used by the market to price and hedge CMBS loans
- Multiple Regression was used to model CMBS spreads using the Fed’s macroeconomic scenario variables
- Noninterest income impact was then calculated using macro-to-micro model output to value warehouse loans in supervisory base, adverse, and severely adverse scenarios

Macro to Micro Model

<table>
<thead>
<tr>
<th>CMBS Credit Spreads</th>
<th>Coefficient</th>
<th>T-Stats</th>
</tr>
</thead>
<tbody>
<tr>
<td>Intercept</td>
<td>.73</td>
<td>2.66</td>
</tr>
<tr>
<td>Market Volatility Index (Qtrly % Change)</td>
<td>.03</td>
<td>3.61</td>
</tr>
<tr>
<td>Commercial Real Estate Price Index (Qtrly % Change)</td>
<td>(2.94)</td>
<td>(1.26)</td>
</tr>
</tbody>
</table>

Fair Value Gain/Loss:
 Loans HFS

![Graph showing credit spreads over time for base, adverse, and severely adverse scenarios]