Market Risk Management

Value at Risk Approach & Capital Adequacy
Caribbean Actuarial Association Annual Conference
Montego Bay Jamaica 2005

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Outlines

- VaR Approach
  - Market Risk Management Development
  - VaR Calculation Methodology
  - VaR Application to Investment Decision
  - VaR Back Testing
  - Stress Testing
- Capital Adequacy
  - Basel International Standards
  - Economic Capital
Financial Risk Management

- Measuring and Managing the risk that arises from the changes in the financial markets:
  -- Market Risk, Liquidity Risk, Credit Risk

- Risk Events: Probability & Severity

“With market and credit risk, you could lose a fortune. With liquidity risk, you could lose the firm”
Market Risk

- It is defined as the potential loss resulting from declining prices in the financial market.

- It includes stochastic market risk factors: Interest Rate, FX, Commodity and Equity.

- Two drivers of the market risk exposures:
  - Investment Position
  - Market Volatility (\( \sigma \))
Market Risk Management Flowchart

Market Risk Exposure - VaR

Component Risk Factors: E, IR, FX, C

Financial Instruments: Stocks, Bonds, Cambio, Derivatives
Market Risk Management Toolbox

- Market Risk Factors Identification
- Sensitivity Analysis
- VaR for Market Risk: Riskmetrics (JP Morgan) 94
- Stress Testing and Scenario Analysis
- Economic Capital Adequacy Level
Market Risk - VaR

- Pioneered by major US banks in the ’90s as derivatives developed
- Defined as the predicted worst-case loss at a specific confidence level over a certain period of time
- Adopted by all major financial institutions – cornerstone of day-to-day market risk measurement
- Usage of VaR as the risk measurement:
  - Across different markets and products
  - Across different time periods
Market Risk Management Development

- Notional Amount
- Sensitivity Analysis
- Value at Risk
What are we calculating?

Probability Distribution Function

![Graph of Probability Distribution Function]

- Value
- Probability

- Probability Distribution Function
VaR Methods

I. Parametric (Delta Normal Analytic Approach)
   Constructs Variance Covariance Matrix
   Used for traditional assets and linear derivatives

II. Monte Carlo Simulation (Simulation Approach)
    Simulates random scenarios, revalues positions
    Used for linear & non-linear instruments

III. Historical Simulation (Simulation Approach)
    Uses historical rates and revalues positions
    Used for linear & non-linear instruments

Illustration
Setting Up the Process

- Variance / Covariance Matrix
  - Data collection
  - Return Calculation
  - Data testing
  - Matrix Construction
  - Positions and Positions Vectors
  - Matrix Multiplication
  - Capital Calculation
  - Interpretation
## VaR Calculation for Fixed Income Portfolio

### Cash Flow Mapping

<table>
<thead>
<tr>
<th></th>
<th>Vol</th>
<th>2007</th>
<th>2011</th>
<th>2017</th>
<th>2022</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOJ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2007</td>
<td>0.42</td>
<td>1</td>
<td>0.71</td>
<td>0.73</td>
<td>0.64</td>
</tr>
<tr>
<td>GOJ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2011</td>
<td>0.26</td>
<td>0.71</td>
<td>1</td>
<td>0.6</td>
<td>0.63</td>
</tr>
<tr>
<td>GOJ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2017</td>
<td>0.24</td>
<td>0.73</td>
<td>0.6</td>
<td>1</td>
<td>0.72</td>
</tr>
<tr>
<td>GOJ</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2022</td>
<td>0.19</td>
<td>0.64</td>
<td>0.63</td>
<td>0.72</td>
<td>1</td>
</tr>
</tbody>
</table>
Flow Diagram Variance/Covariance Analysis

1. Market Data
2. Returns
3. Tests: 1. Graphs 2. 2 std
4. Market Covariance Matrix \( \Sigma \)
5. Position Data
6. Position Vector (includes DV01's)
7. Matrix Multiplication: \( X'\Sigma X \)

- Portfolio VaR
- Absolute Sub-Portfolio VaR
- Marginal Sub-Portfolio VaR
- Scenario Analysis
Flow Diagram Variance/Covariance Analysis

Back Office Systems → Positions/Sensitivity → Historical Data → Data Providers

Determining Possible Outcomes

- Limits Reports
- Stress Tests
- 1% Worst: VaR
- Historical Scenario
- Ad-Hoc Analyses
The Monte Carlo Process

Market Data → Percentage Changes → Tests: 1. Graphs 2. 2 std → Market Covariance Matrix $\Sigma$

Random Uniform Variables → Random Normal Variables → Eigensystem Decomposition → Correlated Random Variables

Repricing → P & L Calculation → Order Statistic VaR
Parameters for VaR

- **Confidence Level**
  - Ranges between 90% and 99%
  - Consider worst-case loss amounts large enough to be material and occur at an observable rate
  - E.g. at 95%: Losses > VaR once in 20 trading days

- **Forecast Horizon**
  - Active organizations use 1 day forecast—trading positions change daily
  - Investment Managers use 1-month forecast
  - The time to liquidate or hedge the portfolio

- **Decay Factor**
  - Ranges between 0.9 to 1 by applying EWMA
  - Forecasting future Vol & Corr by using historical data
VaR Approach to Investment

- Relative VaR – risk of underperformance relative to a benchmark

<table>
<thead>
<tr>
<th>Portfolio</th>
<th>VaR %</th>
<th>Benchmark</th>
<th>Relative VaR</th>
</tr>
</thead>
<tbody>
<tr>
<td>U.S. Equities</td>
<td>10</td>
<td>S&amp;P 500 Index</td>
<td>3</td>
</tr>
<tr>
<td>Global Equities</td>
<td>11</td>
<td>MS EAFE Index</td>
<td>1</td>
</tr>
<tr>
<td>Global Fixed Income</td>
<td>5</td>
<td>JPM GBI+ Index</td>
<td>4</td>
</tr>
<tr>
<td>Total Portfolio</td>
<td>8</td>
<td>Custom Global Index</td>
<td>3</td>
</tr>
</tbody>
</table>
Relative VaR

- Report reveals important differences between VaR and Relative VaR
- Global Equities has the stand-alone VaR (11%), but relative to its benchmark, the smallest relative VaR (1%)
- Global FI Portfolio has smallest stand-alone VaR (5%) but highest relative VaR (4%)
Marginal VaR

- Measures how much risk a position adds to a portfolio or how much Portfolio VaR would change if a position is removed

**Example**

<table>
<thead>
<tr>
<th>Position</th>
<th>Market Value MM$</th>
<th>VaR MM$</th>
<th>Marginal VaR MM$</th>
</tr>
</thead>
<tbody>
<tr>
<td>GOJ 2017</td>
<td>$25</td>
<td>$1.9</td>
<td>$0.3</td>
</tr>
<tr>
<td>10-yr US Tr.</td>
<td>$98</td>
<td>$0.8</td>
<td>$0.6</td>
</tr>
</tbody>
</table>
Marginal VaR

- Although GOJ 2017 has the greater stand-alone VaR, its contribution to portfolio VaR is less than the T-Note’s contribution.
- Often the largest stand-alone risk positions are not the greatest contributors of risk – hedges have a negative marginal VaR.
- Identifies which position to eliminate entirely in order to most effectively reduce risk.
Incremental VaR

- Closely related to Marginal VaR
- Measures the impact of small changes in position weighting
- Increase position weight by $1 and measure the change in overall portfolio VaR – multiply this change by position weighting
- Sum of all Incremental VaRs add up to total Portfolio VaR
## Risk Contribution Report

**Source: Risk Management - A Practical Guide - RMG**

<table>
<thead>
<tr>
<th>Region</th>
<th>Market Value $MM</th>
<th>VaR $MM</th>
<th>Marginal VaR $MM</th>
<th>Increm. VaR $MM</th>
<th>Contribution to Risk</th>
</tr>
</thead>
<tbody>
<tr>
<td>US</td>
<td>$71.77</td>
<td>$574,194</td>
<td>$222,075</td>
<td>$378,341</td>
<td>25%</td>
</tr>
<tr>
<td>Lat. America</td>
<td>$10.26</td>
<td>$512,944</td>
<td>$220,114</td>
<td>$369,626</td>
<td>25%</td>
</tr>
<tr>
<td>Europe</td>
<td>$64.60</td>
<td>$581,404</td>
<td>$204,358</td>
<td>$343,237</td>
<td>23%</td>
</tr>
<tr>
<td>Asia ex Jap</td>
<td>$12.69</td>
<td>$589,734</td>
<td>$196,046</td>
<td>$317,346</td>
<td>21%</td>
</tr>
<tr>
<td>East Europe</td>
<td>$1.95</td>
<td>$116,932</td>
<td>$31,050</td>
<td>$40,322</td>
<td>3%</td>
</tr>
<tr>
<td>Japan</td>
<td>$19.57</td>
<td>$195,694</td>
<td>$48,012</td>
<td>$30,068</td>
<td>2%</td>
</tr>
<tr>
<td>Africa</td>
<td>$4.67</td>
<td>$93,387</td>
<td>$24,423</td>
<td>$24,163</td>
<td>2%</td>
</tr>
<tr>
<td>Div. Benefit</td>
<td>($1,161,186)</td>
<td>($1,161,186)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Aggregate</td>
<td>$185.52</td>
<td>$1,503,103</td>
<td>$1,503,103</td>
<td></td>
<td>100%</td>
</tr>
</tbody>
</table>
VaR Analysis

- Although Asia ex Japan has the largest stand-alone VaR, it is the fourth largest contributor to risk, as measured by incremental VaR.
- The best 3 opportunities for reducing risk through hedges lie in US, Latam & Europe.
- Diversification benefit = Overall Portfolio VaR – Sum of individual VaRs.
Back Testing

- Compares realized trading results with model-generated risk measures
  - To evaluate new models
  - Reassess accuracy of existing models
- Banks back test risk models on a monthly or quarterly basis – probe results
- Are exception percentages within tolerance? E.g. for a 1-day 95% confidence VaR, you should expect about 5% downside exception over time
- Parameter Calibration
The US Dollar VaR Report

- 99% Positive Daily Profit & Loss
- Series 5
- Series 6
- 99% Negative VaR
Limitations of VaR

- Fundamental assumption that future risk can be predicted from historical distribution

- Vulnerable to regime shifts & sudden changes in market behavior

- Makes assumption and subjective judgment for risk factors’ volatility & correlation

- VaR calculated by different methods have different limitations
Do Not Rely Entirely On VaR!!

“VaR gets me to 95% confidence. I pay my Risk Managers good salaries to look after the remaining 5%” – Dennis Weatherstone, former CEO, JP Morgan
Stress Testing

- Designed to estimate potential economic losses in abnormal markets
- Extreme market movements occur far more frequently than a normal distribution suggest
- Provides a more comprehensive picture of risk
What Makes A Good Stress Test?

- Relevant to current positions
- Consider changes in all relevant market rates
- Examine potential regime shifts
- Spur discussion
- Consider market illiquidity
- Consider the interplay of market & credit risk
## Standard Stress Test Scenario

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parallel Yield Curve Shift</td>
<td>100bps</td>
</tr>
<tr>
<td>Yield Curve Twist</td>
<td>25 bps</td>
</tr>
<tr>
<td>Equity Index</td>
<td>10%</td>
</tr>
<tr>
<td>Implied Volatility</td>
<td>20%</td>
</tr>
</tbody>
</table>
Steps for Stress Testing

- Step 1 – Generate scenarios
  - Credible worst case scenarios relevant to portfolio

- Step 2 - Revalue Portfolio
  - Mark to Market all financial instruments

- Step 3 – Summarize results
  - Loss for each stress scenario
  - How to use the results from Stress Testing
Example – Stress test of GOJ yield curve

Step 1 – Generate Scenarios

Scenario A: USD yield curve moves up in a parallel way by **200 bps**
Scenario B: USD yield curve moves up in a parallel way by **300 bps**
Scenario C: JMD yield curve moves up in a parallel way by **500 bps**
Scenario D: JMD yield curve moves up in a parallel way by **1000 bps**
Scenario E: Probable Worse Case
### Example – Stress Test of GOJ Yield Curve

#### Step 2 - Revaluation

<table>
<thead>
<tr>
<th>Scenario</th>
<th>Decline in Value</th>
<th>% economic capital</th>
<th>Within Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Scenario A: USD yield curve moves up in a parallel way by <strong>200 bps</strong></td>
<td>$1.6 B</td>
<td>45.5%</td>
<td>Y</td>
</tr>
<tr>
<td>Scenario B: USD yield curve moves up in a parallel way by <strong>300 bps</strong></td>
<td>$2.3 B</td>
<td>66%</td>
<td>N</td>
</tr>
<tr>
<td>Scenario C: JMD yield curve moves up in a parallel way by <strong>500 bps</strong></td>
<td>$830 M</td>
<td>24%</td>
<td>Y</td>
</tr>
<tr>
<td>Scenario D: JMD yield curve moves up in a parallel way by <strong>1000 bps</strong></td>
<td>$1.5 B</td>
<td>44%</td>
<td>Y</td>
</tr>
<tr>
<td>Scenario E: Probable Worse Case</td>
<td>$1.8 B</td>
<td>53%</td>
<td>N</td>
</tr>
<tr>
<td>JMD appreciates by 5%</td>
<td>$1.1 B</td>
<td>32%</td>
<td>Y</td>
</tr>
</tbody>
</table>
Example – Stress Test of GOJ Yield Curve

Step 3 – Summarize Results

- Summarize Results
  - The severity of the possible stress tests.
    - Are they within the limit?
  - The probability of the occurrence of these events
  - The major risk contributor
    - Under what scenario would the impact be like the one observed?
  - The possible action plan:
    - Insurance, Exposure reducing, Limit Policy
Risk Reporting

- Efficient risk reporting process – foundation for clear and timely communication of risk across enterprise (Corporate, Business Unit, Trading Desk)

- What makes a good risk report?
  - Timely
  - Reasonably accurate
  - Highlight portfolio risk concentrations
  - Include a written commentary
  - Be concise
From Chase Manhattan’s Annual Report:

“Chase conducts daily VaR backtesting for both regulatory compliance with the Basle Committee on Banking Supervision market risk capital rules and for internal evaluation of VaR against trading revenue. During the year, a daily trading loss exceeded that year’s trading VaR on 2 days. This compares to an expected number of approximately 3 days. Considering the unsettled markets during the year, Chase believes its VaR model performed at a very high level of accuracy during the year.”
The New Basel Accord

3 pillars

- Pillar 1: Capital Adequacy
  - Min. of 8% (but now credit, market & operational)

- Pillar 2: Supervisory Review
  - Supervisors responsible for ensuring banks have sound internal processes to assess capital adequacy

- Pillar 3: Market Discipline
  - Enhanced disclosure by banks
  - Sets out disclosure requirements
Capital Adequacy

\[
\text{CAPITAL REQUIRED} = \text{EXPOSURE} \times \text{RISK WEIGHT} = \times 8\%
\]

- **Capital Required**
  - **Exposure**
  - **Risk Weight**

**Basel II: Changes**
- *Revised and new approaches incorporated*
- *Relatively unchanged*
- *New*
Risk Weighted Assets

$$RWA = \text{Banking Book RWA} + \text{Trading Book RWA}$$

Banking Book RWA = Position * Risk Weighting

Trading Book RWA = Market Risk Capital / 8%
Market Risk Capital

- Use of VaR
- Daily calculation
- 99% confidence interval
- 10-day time horizon
- Flexibility in methodology used – should take into account correlations and non-linear risk characteristics
The VaR Capital for Total Portfolio

Market Risk Capital Level by Basel Accord:

\[
MRC = \max \left\{ K \times \frac{1}{60} \times \sum_{n=1}^{60} \text{VaR}_{(99\%, 10\text{ days})}^{(n, \text{lastday})}, \text{VaR}_{(lastday)} \right\} + \text{Spec}
\]
Economic Capital Definition

Financial Resource allocated to offset potential loss

Economic Capital vs. Regulatory Capital

Economic Capital vs. Accounting Capital
Function of Economic Capital

- To Address the unexpected loss at certain confidential level for certain time horizon

- Ensure solvency and stability of Financial Institutions in cases of market shocks

- May be aligned with the firm’s risk appetite
Risk Management is a continuous process

Diagram:
- Define
- Measure
- Manage
- Monitor

The process is cyclical, with outputs from one stage feeding into the next.
March 16 2005 VaR Report: VaR
March 16 2005 VaR Report: VaR
March 16 2005 VaR Report: Duration

Duration JMB's Default Risk Setting, decay factor 0.94

Legend

<table>
<thead>
<tr>
<th>Color</th>
<th>Label</th>
<th>Value</th>
<th>Percent</th>
</tr>
</thead>
<tbody>
<tr>
<td>11.625% 2022</td>
<td>Jaman 11.625% 2022</td>
<td>8.21</td>
<td>30%</td>
</tr>
<tr>
<td>10.625% 2017</td>
<td>Jaman 10.625% 2017</td>
<td>7.04</td>
<td>25%</td>
</tr>
<tr>
<td>11.75% 2011</td>
<td>Jaman 11.75% 2011</td>
<td>4.48</td>
<td>16%</td>
</tr>
<tr>
<td>GOJ 10.50% 2009</td>
<td>Local Bond</td>
<td>3.62</td>
<td>13%</td>
</tr>
<tr>
<td>12.75% 2007</td>
<td>Jaman 12.75% 2007</td>
<td>2.15</td>
<td>8%</td>
</tr>
<tr>
<td>Local Bond 11.75% 2006</td>
<td>Jaman 2006</td>
<td>1.41</td>
<td>5%</td>
</tr>
<tr>
<td>Index Bond 2005 11.25%</td>
<td>Jaman 2005</td>
<td>0.66</td>
<td>2%</td>
</tr>
<tr>
<td>Jaman 10.875% 2005</td>
<td>Local Bond 2005</td>
<td>0.24</td>
<td>1%</td>
</tr>
</tbody>
</table>
March 16 2005 VaR Report: Historical Simulation
Historical Events

- May 19th 2003: 2.1 Billion
  8.94 Sigma
- March 28th 2003: 1.5 Billion
  7.15 Sigma
- May 20th 2003: 1.45 Billion
  6.87 Sigma
  99 Percentile 4.78 Sigma 1.01 Billion
March 16 2005 VaR Report: Monte Carlo Simulation