Implementing RAROC across the Enterprise ...

an open road

RISK '99 8-9 June 1999, Boston Organized by *Risk* Conferences Michael K. Ong Senior VP & Head Enterprise Risk Management ABN AMRO Bank



RAROC is the "glue" for **Enterprise-Wide Risk Management**





What is RAROC?

- <u>Risk-Adjusted Return On Capital</u> -- RARORAC, RAPM, etc. *They are all the same*.
- Defines "risk" as potential for *unexpected* financial loss over and above that which has been priced into transaction margins and therefore provided for.
- The aim of RAROC is to adjust returns by *expected losses* and to provide a buffer capital based on *unexpected losses*.
- Implementation of RAROC is driven by the desire to look at risk on a portfolio basis rather than on "silos of risks".



What is RAROC?

• Risk-adjusted performance ratio:

Risk-Adjusted ReturnRevenues
+/- Treasury Transfer Prices
- Expenses
- Expected LossesRisk or Economic CapitalCapital for Unexpected Losses
Credit Risk
Market Risk
Operational Risk
etc.



The RAROC Equation Dissected

RAROC =

$\sum_{i} [Expected Net Revenue]_{i} - (EL_{MR} + EL_{CR} + EL_{OR} + ...)$

$EC_{MR} + EC_{CR} + EC_{OR} + \dots$

where

- EL_{MR} : The *Expected Loss* for market risk in the Trading Book
- EL_{CR} : The *Expected Loss* for credit risk in the Banking Book due to obligor defaults
- EC_{MR} : The *Economic Capital* for the Trading Book which is some appropriately scaled-up VaR matching the confidence level and time period of the analysis horizon
- EC_{CR} : Some multiple of the Unexpected Loss for the Banking Book



Loss Distributions





Broadly speaking, a typical bank has 2 generalized portfolios:

Trading Book

| | 1855 245 JULS 250 SETS 255 | UP 1/4 3/4 UHOH 1/2 UP 1/ | 2 | | | | CE UKRES C I NEUSPRIPER GREENSPRIM |
|-------------------|----------------------------------|---|---|---|--|----------------------------|--|
| | | | -31. | MK 370.2 | FVH 102-315. | TYH 103-1 | SPREA |
| 5)) 5+ | WOATS MAY 1100 1100 | SP 100 INDEX 5685 5227 5652 4314 | SP 600 INDEX 8765 8316 8738 422+ | s+P500 JUN 9250 8650 9180 455+ | 000 JONES 40217 39830 40190 357+ | 9372 9365 9369 2- | RODOLL/ 9345 9330 9341 3 |

Capital Markets Activities

- Market risk due to changes in market rates
- Specific issuer risk
- Counter-party default risk

Banking Book



Illiquid assets, e.g. bank loans, asset-based lending, leasing, etc. which are not marked-to-market

- Obligor default risk
- Potentially, some market risk if we evolve from accrued accounting to MTM



Generally speaking,

Banking Book >> Trading Book

We definitely need to pay more attention to the credit risks embedded in the Banking Book.



Integrated Framework



In an integrated framework, however

 $VaR \neq f(UL_{MR}) + f(UL_{CR}) + \dots$

but more like

 $VaR = G (MR \& CR \& \dots).$

But we are not there yet!



Short of an integrated framework, approximate as follows:

| | Trading Book | Banking Book |
|----|---|---|
| EL | Due to counter-party credit risk (potential future exposure of trading positions) | $EL_{P} \equiv \sum_{i} EL_{i} = \sum_{i} (AE_{i} \cdot LGD_{i} \cdot EDF_{i})$ |
| UL | Mult $VaR_{one-day} \cdot \sqrt{T}$ assuming VaR contains market risk, specific risk, and counter-party default risk. | $UL_{p} = \left[\sum_{i} \sum_{j} \rho_{ij} UL_{i} UL_{j}\right]^{1/2}, \text{ where}$ $UL_{i} = AE_{i} \cdot \sqrt{EDF_{i} \cdot \sigma_{LGD(i)}^{2} + LGD_{i}^{2} \cdot \sigma_{EDF(i)}^{2}}$ and ρ_{ij} denotes the <i>correlation of default</i> between asset <i>i</i> and <i>j</i> . |



Some Predictions...





• There is widespread recognition that the 1988 Basle Accord has serious flaws, resulting in "game theory" and other practices.

• We should definitely not use regulatory capital as the underlying measure of risk and return.



Some RAROC Results Demonstrate the Shortcomings of the Current Regulatory Regime

| | Return M | eas | ures | | | | | | | | | | [| ''W | oreo" | | |
|---------|----------|--------|-----------|--------|-----------|--------|-----------|--------|-----------|----|----------|-------------------------------|--------------|------------|-----------|--------------|-----------|
| L | | | | | | | | | Δητ | | | | | vv | 5180 | | |
| | | | | | | | | | Ally | | | | | Credit | Name | S | |
| , | | | | | | | 0 | bs | ervation | 18 | ? | | | | | | |
| AROC | ROAC | Expe | cted Loss | Ris | k Capital | RE | G Capital | Re | evenue | | Cust NO | Cust Name | Industry | Maturity | Risk Code | Default Prob | babi |
| -2.55% | 13.83% | \$ | 49,896 | \$ | 1,044,446 | \$ | 168,072 | \$ | 23,247 | | 00700819 | BANCO DE CREDITO DEL PERU | REGFINANCE | 1.00 | В | 0.9 | 5% |
| 15.65% | 40.48% | \$ | 36,195 | \$ | 217,199 | \$ | 173,354 | \$ | 70,181 | | 00420921 | TEXAS PETROCHEMICALS CORP. | CHEMICALSF | 5.00 | 5 | 4.8 | 5% |
| 195.76% | 91.22% | \$ | 56,138 | \$ | 589,678 | \$ | 1,326,974 | \$ | 1,210,503 | | 00597406 | AVANTEL S.A. | REGUTILITY | 2.22 | В | 0.9 | 5% |
| -30.75% | 32.90% | \$ | 431,917 | \$ | 983,894 | \$ | 393,333 | \$ | 129,404 | | 00675431 | SUNGLASS HUT INTL., INC | RETAILWHOL | 0.95 | 6 | 18.3 | 5% |
| | | | | | | | | | | | | | | | | | |
| 20.66% | 6.62% | \$ | 9,113 | \$ | 236,085 | \$ | 874,286 | \$ | 57,884 | | 00178667 | BRUCEPHIL INC. | FOODBEVTOB | 7.98 | 3 | 0.1 | 5% |
| 14.71% | 3.50% | \$ | 12,309 | \$ | 247,047 | \$ | 1,390,000 | \$ | 48,652 | | 00103039 | BOISE CASCADE CORP | PAPPULPLUM | 4.50 | 3 | 0.1 | 5% |
| 84.82% | 8.31% | \$ | 715 | \$ | 29,196 | \$ | 306,566 | \$ | 25,478 | | 00602108 | VITRO-AMERICAN NATL CAN SA DE | CONSTRUCTR | 0.33 | 3 | 0.0 | 5% |
| 187.92% | 28.82% | \$ | 14,135 | \$ | 360,607 | \$ | 2,400,000 | \$ | 691,774 | | 00678015 | AVANCE TELECOM DE LATINOAME | RICOMMUPROJF | 3.33 | 3 | 0.1 | 5% |
| 5.33% | 2.28% | \$ | 5,680 | \$ | 578,110 | \$ | 1,600,000 | \$ | 36,500 | | 00165956 | AVCO FINANCIAL SERVICES INC | NONREGFINC | 2.59 | 2 | 0.0 | 4% |
| 67.06% | 33.27% | \$ | 401 | \$ | 87,887 | \$ | 178,380 | \$ | 59,342 | | 00731277 | AT&T / BANK OF CHINA | REGFINANCE | 4.04 | 1 | 0.0 | 1% |
| 42 500/ | | ¢ | 15 011 | ¢ | 490.050 | ¢ | | ¢ | 44 444 | | 00400750 | | | 0.50 | | 0.4 | 70/ |
| 13.38% | #DIV/0! | ф Ф | 15,311 | ¢ ¢ | 109,952 | ¢ ¢ | | Φ | 41,111 | | 00409758 | | | 0.50 | 4 | 0.4 | 1 % |
| 51.31% | #DIV/0! | ф Ф | 3,525 | ¢ ¢ | 201,025 | ¢ ¢ | - | D C | 118,850 | | 00427845 | | | 0.77 | 4 | 0.0 | 5% 50/ |
| -1.51% | #DIV/0! | ð | 9,050 | Э | 234,440 | Ф | - | Э | 5,520 | | 00410713 | DUOTI DUAKE ALLEN ING | FOODREVIOR | 1.00 | | 0.1 | 5% |

S &P Default Prob 1997

R

| Risk Code | Default Probability |
|-----------|---------------------|
| 1 | 0.01% |
| 2 | 0.04% |
| 3 | 0.15% |
| 4 | 0.95% |
| 5 | 4.85% |
| 6 | 19.25% |
| 7 | 100.00% |
| 8 | 100.00% |
| A | 0.04% |
| в | 0.95% |
| С | 4.85% |
| 0 | 4.21% |
| x | 4 21% |

No Regulatory Capital is required for: a. Commitments < 1 yr b. Facilities w/Cash Collateral "Better" Credit Names



Risk-Adjusted Pricing: The Loan Pricing Calculator

Loan Pricing Calculator

(With Respect to 31 May, 1998 Loan Portfolio)

Enter the All Input Data, Press F9 to Calculate

| Input: New | v Facility Information | | | | | |
|------------|------------------------|-------------|----------------------|--------|--------------------|------|
| | Customer No | 00184233 | Industry SIC Code | 5122 | Internal Risk Code | 4+ |
| | Customer Name | DUMMY CORP. | | | | |
| | Committment in \$ | 30,000,000 | Commitment Fee in bp | 5 | Maturity in years | 1.00 |
| | Outstanding in \$ | 10,000,000 | Up Front Fee in \$ | 20,000 | Secured ? | N |

| Output | | | Existing Customer Number, | | | |
|--------|------------------------------|------------|---------------------------|-------------|----------------------|------|
| | Exposure Upon Default | 21,400,000 | Customer Name | DUMMY CORP. | | |
| | Expected Loss | 65,240 | Commitment | 21,500,000 | SIC | 5122 |
| | Unexpected Loss Contribution | 131,443 | Outstanding | 17,766,667 | Customer Risk Rating | B4+ |
| | Capital | 952,959 | RAROC | -5.27% | | |

1) Enter Spread, Calculate RAROC for this Deal

| Input | Loan Spread in bp | 125 | | |
|--------|-------------------|---------|----------------|-------|
| Output | Revenue | 160,000 | | |
| | New Deal RAROC | 9.94% | Customer RAROC | 2.76% |

2) Enter Target RAROC, Calculate Required Spread

| Input | New deal Target RAROC | 13.00% | | |
|--------|----------------------------|---------|----------------|-------|
| Output | Required Revenue | 189,124 | | |
| | Required Loan Spread in bp | 154 | Customer RAROC | 4.38% |



Regarding credit risk, there are some serious flaws^{*} in the 1988 Basle Accord:

- Limited differentiation of credit risk
- Static measure of default risk.
- No recognition of the term structure of credit risk.
- Simplified potential future counter-party risk calculations.
- Constraints on an integrated view of credit risk.
- Lack of recognition of portfolio diversification effects.

*Credit Risk and Regulatory Capital, ISDA, March 1998.



Consequences of these flaws:

- Inhibits transparency by discouraging the active marking-to -market of the banking book.
- Regulatory capital rules produce a distorted assessment of actual risks, leading to a misallocation of capital.
- Required capital ratios are arbitrary, devoid of probability for insolvency.
- Imprudently allows "game theory" to occur regulatory arbitrages in the form of credit derivatives and securitization programs.
- Regulatory supervisors tend to engage in academic exercises, and do not adequately keep up with industry developments and innovations.



- We are at the cusp of an imminent regulatory capital reform. Some hints are:
 - -- Basle Committee April 1999 release on "Credit Risk Modelling: Current Practices and Applications".
 - -- Industry lobby groups and portfolio exercises.
 - -- Availability of more vendor tools.
 - -- Increasing use/development of Internal Models (more for credit risk this time) in major banks.
 - -- More visible discussion on operational risk management and measurement.



Federal Reserve System Task Force on Internal Credit Risk Models (May, 1998)^{*} identified two key consequences:

• The regulatory measures of capital may not represent a bank's true capacity to absorb unexpected losses.

• The denominator of the risk-based capital ratios, i.e., the total risk-weighted assets, may not be an accurate measure of total risk.

*Credit Risk Models at Major U.S. Banking Institutions: Current State of the Art and Implications for Assessments of Capital Adequacy, Federal Reserve Board, May 1998.



Basle Committee report on "Credit Risk Modelling: Current Practices and Applications" issued April 1999:

"The report notes that credit risk models offer a tailored and flexible approach to credit risk measurement and management. It concludes that models are an important tool in risk management as they provide estimates of credit risk that are influenced by and responsive to shifts in business line, credit quality, market variables and the economic environment."



"The report notes that a number of hurdles, principally concerning data limitations and model validation, must be cleared before credit risk models can play a part in setting regulatory capital requirements for credit risk."



What risk measures, therefore, must be introduced in order to come up with a better assessment of risk capital?

For better or for worse, internal VaR models for market risk are now widely accepted. We must ensure that the internal market risk VaR models also capture *specific issuer risk* and *counter-party credit risk*.

How about credit risk for the Banking Book?



Two Important Conditions for a Sound Internal Credit Risk Model

- An internal credit risk model must be able to accurately assess and quantify the instrinsic credit risk embedded in the bank's portfolio. In so doing, introduce both *quantitative* and *qualitative* measures that can facilitate prudential portfolio risk management.
- Ultimately, an internal credit risk model must provide a mechanism with which economic capital requirement of the bank can be determined and the resulting capital allocation framework be robust enough to be used for *risk-adjusted pricing* and other strategic purposes.



Essential Components of a Sound Internal Model



RISK PUBLICATIONS: BOOKS



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Internal Credit Risk Models

Capital Allocation and Performance Measurement Author: Dr Michael K. Ong

'The most accurate information regarding risks is likely to reside within a bank's own internal risk measurement and management systems' (Federal Reserve Board 1998) The debacle over 1996 Amendment to the Basle Accord in relation to market risk has led banks to rethink their strategies concerning the management of credit risk. Consequently, and in response to the recognition of the inadequacy of the risk-based capital rules, banks are developing their own internal risk models for quantifying the credit risk in their books. This new title from Risk Books aids the development of internal models for credit risk as the risk management tool of the banking book. It provides an in-depth analysis of credit risk management, looks at methods of approaches, and provides a critical analysis of the Basle requirements.

Key features:

- Provides a historical overview of the market responses to regulatory directives from the 1988 Basle Capital Accord to the present day.
- Explains the fundamentals of the quantitative building blocks and applies them to internal credit risk modelling.
- Provides the relevant tools for building internal models with simple explanations and accessible mathematics.

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For credit risk we need to revisit the numerator and denominator of the RAROC equation.

Here they are ...





Risk-Adjusted Return

Risk or Economic Capital





Risk-Adjusted Return

Risk or Economic Capital



Denominator

Risk-Adjusted Return

Risk or Economic Capital





How Should One Choose the Loss Density Function $f(\tilde{L})$?

• It is definitely not true that $f(\tilde{L}) \sim N(\mu_{\tilde{L}}, \sigma_{\tilde{L}})$. This may be fine for market risk.

• $f(\widetilde{L})$ has an extremely fat and heavy upper tail.

-- fat-tailedness or leptokurtic means a kurtosis > 3. -- heavy upper tail means $\int_{0}^{\infty} \widetilde{L}^{j} f(\widetilde{L}) d\widetilde{L} \rightarrow +\infty$ for some positive integer j.

• **Beware:** 3 standard deviations is not sufficient for credit risk.

• $f(\tilde{L})$ can be estimated using *Extreme Value Theory*. -- e.g. Pareto, Frechet, Gumbel, etc.



Fitting Credit Loss Distribution using Extreme Value Theory

Simulated Loss Distribution for a Sample Portfolio





The *Generalized Pareto Distribution* is a family with three degrees of freedom,

$$G_{\xi,\mu,\psi}(x) = \exp\left\{-\left(1+\xi\cdot\frac{x-\mu}{\psi}\right)_{+}^{-1/\xi}\right\}, \text{ for } \xi \neq 0$$

with three degrees of freedom given by: the *scale* parameter $\psi > 0$, the *location* parameter $\mu \in R$, and the *shape* parameter $\xi \in R$.

A simpler functional form commonly used is given by

$$G_{\xi,\mu,\psi}(x) = 1 - \left(1 + \xi \cdot \frac{x - \mu}{\psi}\right)_{+}^{-1/\xi}, \text{ for } \xi \neq 0$$



Fitting the Generalized Pareto Distribution to the Simulated Loss Distribution





Portfolio RAROC: UL and RC Unexpected Loss

Unexpected Loss (UL) needs to be considered at two different levels:

single asset, and
within an aggregate.

The Unexpected Loss UL_P of the portfolio is the volatility of the potential loss of the portfolio around the Expected Loss (EL), i.e.,

$$UL_P \equiv \left[\sum_i \sum_j \rho_{ij} UL_i UL_j\right]^{1/2}$$



Portfolio RAROC: UL and RC Risk Contribution

Because of diversification effects due to correlation, observe that

$$UL_P << \sum_i UL_i$$
,

which implies that only a portion of an individual asset's UL_i contributes to the portfolio risk. This portion is called the **Risk Contribution** (RC) and is defined by

$$RC_{i} \equiv UL_{i} \frac{\partial UL_{P}}{\partial UL_{i}}$$
$$= \frac{UL_{i} \sum_{j} UL_{j} \rho_{ij}}{UL_{P}}$$



Portfolio RAROC: UL and RC Risk Contribution

Risk Contribution is a measure of the <u>undiversified</u> risk of an asset in the portfolio. In fact, one can show the relationship

$$UL_P = \sum_i RC_i$$
.

Note: $\frac{RC_i}{UL_i}$ is the proportion of asset *i* not diversified away by the portfolio.



Consequence of RC and UL

Correlation of default ρ_{ij} is very important when assessing the true risk of the portfolio as quantified by the portfolio's Unexpected Loss UL_P .



Correlation of Defaults

- Only *asset correlations* can be implied from the market empirically.
- *Pair-wise* correlation of default either needs to be calculated or implied assuming some *joint-default distribution*. The joint-default distribution is probably normal but who knows?

$$\rho_{ij} = \frac{P(D_i \cdot D_j) - EDF_i \cdot EDF_j}{\sqrt{EDF_i(1 - EDF_i)} \cdot \sqrt{EDF_j(1 - EDF_j)}}$$

where $P(D_i \cdot D_j) = EDF_i + EDF_j - P(D_i + D_j)$, so we need to know only the probability that at least one default has occurred.



Correlation of Defaults

- There is a common myth that the typical range of default correlation is between 1% and 5%, but this is more an "average" range since larger covariances do occur.
- It is easier to impute default correlations in a two-state default process.
- For a multi-state default process, the correlation of *joint credit quality movement* must first be inferred through some mechanism.



Sample Correlation Matrix

S &P 1997

| Industry Default Correlation Matrix | | | | | | | | |
|--|----|-------|-------|-------|-------|-------|-------|-------|
| | | 1 | 2 | 3 | 4 | 5 | 6 | 7 |
| S&P Automobiles Index (.SPAUTO) | 1 | 11.0% | 1.0% | 1.1% | 1.1% | 0.6% | 0.3% | 0.5% |
| S&P Financial Index (.SPF) | 2 | 1.0% | 13.9% | 2.1% | 2.2% | 1.5% | 1.6% | 2.5% |
| S&P Building Materials Index (.SPBULD) | 3 | 1.1% | 2.1% | 10.6% | 1.7% | 0.8% | 1.2% | 1.2% |
| S&P Chemicals Index (.SPCHEM) | 4 | 1.1% | 2.2% | 1.7% | 13.0% | 1.1% | 1.6% | 1.6% |
| S&P Electronics (Instrumentation) (.SPELCI) | 5 | 0.6% | 1.5% | 0.8% | 1.1% | 11.1% | 0.5% | 1.1% |
| S&P Energy Index (.SPEN) | 6 | 0.3% | 1.6% | 1.2% | 1.6% | 0.5% | 10.2% | 0.7% |
| S&P Entertainment Index (.SPENTE) | 7 | 0.5% | 2.5% | 1.2% | 1.6% | 1.1% | 0.7% | 11.3% |
| S&P Foods Index (.SPFOOD) | 8 | 0.1% | 2.4% | 0.5% | 0.9% | 1.0% | 1.0% | 2.2% |
| S&P Health Care Index (.SPHC) | 9 | 0.1% | 3.1% | 0.6% | 0.9% | 1.4% | 1.0% | 2.7% |
| S&P Insurance Composite Index (.SPINS) | 10 | 0.3% | 5.6% | 1.1% | 0.9% | 0.5% | 0.8% | 1.2% |
| S&P Machinery (Diversified) (.SPMCHD) | 11 | 2.6% | 1.9% | 2.3% | 3.1% | 1.2% | 1.4% | 1.4% |
| S&P Manufacturing (Diversified) (.SPMAND) | 12 | 1.7% | 4.0% | 2.9% | 4.3% | 1.7% | 1.2% | 2.2% |
| S&P Metals Mining Index (.SPMETL) | 13 | 1.2% | 1.0% | 1.0% | 2.7% | 1.2% | 0.4% | 0.9% |
| S&P Oil & Gas (Refining & Marketing) (.SPENRM) | 14 | 0.8% | 0.9% | 1.1% | 1.8% | 1.1% | 2.0% | 1.1% |
| S&P Paper & Forest Products Index (.SPPAPR) | 15 | 1.3% | 0.8% | 1.2% | 2.8% | 0.7% | 0.3% | 0.7% |
| S&P Publishing Index (.SPPUBL) | 16 | 0.4% | 1.8% | 0.9% | 1.3% | 0.8% | 0.7% | 1.9% |
| S&P Technology Index (.SPTK) | 17 | 0.8% | 1.8% | 1.2% | 1.4% | 3.8% | 0.3% | 2.0% |
| S&P Telecommunications (Long Distance) (.SPTELC) | 18 | 0.4% | 2.0% | 0.4% | 0.6% | 0.6% | 0.8% | 1.4% |
| S&P Textiles (Apparel) (.SPTEXT) | 19 | 0.3% | 0.8% | 0.5% | 0.6% | 0.0% | 0.3% | 0.5% |
| S&P Transport Index (.SPT) | 20 | 2.2% | 3.5% | 3.0% | 3.8% | 2.0% | 1.5% | 2.3% |
| S&P Utilities Index (.SPU) | 21 | 0.2% | 3.1% | 0.6% | 0.4% | 0.4% | 1.4% | 0.9% |
| Other | 22 | 2.0% | 2.0% | 2.0% | 2.0% | 2.0% | 2.0% | 2.0% |



Conclusion:

Where does the open road lead us to?

- Enterprise-wide RAROC will be driven by Internal VaR Models and Internal Credit Risk Models.
- Pending regulatory acceptance, risk-adjusted pricing will force the transparent MTM valuation of the Banking Book.
- The desire to implement RAPM within banks will encourage banks to diligently clean up their system infrastructure, thereby facilitating operational risk measurement / management.
- As the integration of market risk and credit risk becomes more coherent, liquidity issues will need to be addressed more aggressively.

