Yet Another New Paradigm
Multi-dimensional Strategic Risk Management

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My Background

- Executive Director and Founder of the RisKontrol Group GmbH in Bern, Switzerland
- Studies for CB of India, Colombia, SWFs including Norway, ECB book, and others
- Reinsurance papers and applications
- 24 years at the World Bank
- Reserves management advisor for IMF
- Professor of OR at George Washington University
- Independent workshops in MP Modeling in Economics and Finance
- Ph.D. Mathematical Programming
- IBM Scientific Center and Social Systems Research Institute
Outline

• Failures of risk management in the crisis
• Using dynamic stochastic optimization (DSP) to address failures
• Using DSP to formulate multiple strategic objectives in “CEO speak”
• Example: The case of the Reserve Bank of India
Crises

Be prepared for the next unexpected financial and economic disaster.

Control the right risks over changing regimes and address RM failures.
A famous professor named Rene M. Stulz listed the risk management failures and remedies in the financial crisis.

1. Failure to use appropriate risk metrics
2. Mismeasurement of known risks
3. Mismeasurement stemming from overlooked risks
4. Failure in communicating risks to top management
5. Failure in monitoring and managing risks

Our Focus

Suggested Remedies
1. Look at longer horizon
2. More comprehensive integrated view of risks
3. Stress tests for crisis and make contingencies
4. Use measures better than VaR
5. Contingency plans for withdrawal of liquidity
6. Consider risk concentrations
7. Beware of herding
8. Consider scenarios, extreme events, and reverse stress tests
Communication Issues

Can top management and risk managers talk to one another?

• Top management and board set strategy – they identify competitive advantage and the risks its investors are paying the firm to take.
• In this context, risk management must
  • Provide timely information to right people
  • Make them understand the risks
  • No “black boxes’
  • Right level of risks
  • [use right terminology] (BKS)
  • [use actionable information] (BKS)

Communication: Whose responsibility is it?
Properties of “CEO speak” that need to be captured

- Speak in the words of CEO, board, senior executives, ...
- And report risks in terms of their words ...
- Multiple strategies changing over time
- Long-term AND short-term prospects
- Ratios and indicators; not just return and variance
- All strategic risks taken together (Enterprise RM)
- Separate downside risks from upside opportunities
- Changing financial and economic regimes
Need a paradigm that:

- Can handle multiple kinds of objectives
- Dynamic over medium to long-term
- Allows reevaluating decisions under uncertainty evolving into the future
- Separates downside risks from upside opportunities and handles objectives as same

Leads naturally to dynamic stochastic programming or DSP
DSP Paradigm

To understand the DSP paradigm you must first break out of the M-V and simulation world.

Into a heavenly world of dynamic stochastic optimization where you have:

- Multiple risk constraints on several dimensions simultaneously
- Changing regimes and stochastics
- Controlling failure factors
- Tailored to an institution
- Uncertainty and dynamics unfolding in trees
- Inequalities and optimality
- Integrated risks and factors
- Extremes and non-normal processes

Toilett-humor.com
Exploding Myths

- The “curse of dimensionality”
- Underlying distributions must be right
- Optimization solutions are uncontrollable
- Long time to build DSP model
- DSPs are black boxes
- Scenarios need to be correct
- DSP not tractable

But how do I get the right tree?

I will show you. Besides it is not the tree but the solution you want right!
Multi-factor stochastic differential equations

\[ \frac{ds_i(t)}{s_i(t)} = \mu_i(s, t)dt + \sum_j b_{ij}(s, t)\sigma_j(s, t)d\omega_j(t) \]

- Econometric estimation and others
- Incorporate market information
- Incorporate theories (e.g.
- Integrated with expert opinion
- Change over time or depend on time & level
  - mean-reversion or targeted
  - short and long processes
  - extreme events

The econo-physicist J. L. McCauley says these are the “... best tractable approximation to market dynamics.”

Estimations of these are very useful and flexible.
Balance sheet on each node with cash flows

Use previous to generate a sparse tree with variable probability branches.
Hey, I’m linear!

Why is that important??

Uryasev
CVaR formulation: Can use for objectives. Are linear if loss function is. Can have many. Can shape distribution or equivalently objective. Can minimize CVaR and adjust if infeasible problems.

\[
Z^e \geq \Lambda(X^e) - \text{ALPHA}, \quad Z^e \geq 0, \quad \forall e \in X^t, \quad \text{and for some } t
\]

\[
\sum_{e \in X^t} \pi_{t,e} Z^e \leq \rho(c\text{level}_\rho - \text{ALPHA})
\]

Convex loss function
VaR at solution
Set of events at t
Probability of event
Dummy variable
1-\rho is confidence level
Value based upon \rho
Model can be balance sheet with all kinds of cash flows and assets, liabilities, derivatives and holdings all valued under uncertainty.

- A strategic benchmark with all objectives and risk constraints satisfied
- Asset class composition and relative value
- Interest rate sensitivity and composition
- Impact on liquidity management
- Currency composition and relative value
- All measures to be reported in statistical terms easy to understand such as histograms, densities, various points on the distributions, etc. and various measures
## Multi-dimensional Risk Management

### Failure Factor Remedies

<table>
<thead>
<tr>
<th>Remedies from Rene</th>
<th>Solutions via DSP</th>
</tr>
</thead>
<tbody>
<tr>
<td>Longer horizon</td>
<td>Arbitrary with intermediate rebalancing</td>
</tr>
<tr>
<td>Integrated risks</td>
<td>With small smart trees/scenarios</td>
</tr>
<tr>
<td>Stress tests</td>
<td>Better than pass fail with reverse tests</td>
</tr>
<tr>
<td>Good risk measures</td>
<td>Capture extremes: e.g. CVaR and more</td>
</tr>
<tr>
<td>Plan for liquidity probs</td>
<td>With changing regimes</td>
</tr>
<tr>
<td>Risk concentration probs</td>
<td>With changing regimes and CVaR</td>
</tr>
<tr>
<td>Herding probs</td>
<td>With changing regimes and CVaR</td>
</tr>
<tr>
<td>Extreme events</td>
<td>Low prob/high impact on variable prob tree</td>
</tr>
</tbody>
</table>

And communications
India’s objectives of holding reserves

- maintaining confidence in monetary and exchange rate policies;
- enhancing capacity to intervene in foreign exchange markets;
- limiting external vulnerability by maintaining foreign currency liquidity to absorb shocks during times of crisis;
- providing confidence to the markets, especially credit rating agencies, to the effect that external obligations can always be met, thus reducing the overall costs to the economy or the market participants; and
- adding to the comfort of the market participants, by demonstrating the backing of domestic currency by external assets.

Did well in crisis: dropped deposits with banks from 24% to 2% in 2007.
What can RBI do now? (1)

- Adopt a robust framework and model for strategy formulation
- Clearly enunciate long-term goals, objectives, risks and constraints
- Rapid globalization of Indian economy requires reasonable protection against exogenous shocks
What should RBI do now?(2)

- Bring about more balance between currency, interest rate and market risks
- Add new asset classes and bring about more balance between currency, interest rate and market risks
- Needs an approach that offers flexibility and provides solutions which ensure relative stability at times of stress
- Dynamic stochastic optimization (DSP) provides the answer
Strategies Converted to CVaR

Parameters and Risk factors (1)

- Lower limit on the size of reserves – US$ 200 billion, adjusted for nominal GDP growth(%) 
- Lower limit on the ratio of NFA to (NFA+NDA) 
- Upper limit on the (%) fall in value of reserves in any period in US dollars. 
- Mark-to-market value of reserves not to lag behind the expected value, as measured in the composite currency 

Strategic objectives in CEO speak translated into risk factor inequalities
Parameters and Risk factors (2)

- Foreign currency assets should exceed the amortization of external debt over the next 12 months
- Ratio of short-term external debt to reserves should not exceed a pre-set level

Strategic objectives in CEO speak translated into risk factor inequalities
CEO Rationale

Rationale for Choice of Parameters and Risk Factors (1)

- Preservation of external liquidity and self-insurance properties of reserves
- Limit excessive risk-taking
- Prevent destabilizing expectations in the domestic foreign exchange market from taking hold in the event of any exogenous shock
- Provide flexibility for portfolio rebalancing
Maintain a large pool of liquid assets for providing foreign currency liquidity in the event of a ‘Sudden Stop’.

India faced sudden and sharp drop in certain key capital inflows in the wake of the collapse of Lehman Brothers in September, 2008 resulting in shortage of forex funds amongst banks and non-bank corporates with potential for disruption in the credit and foreign exchange market.
### Capital Flow items associated with ‘Sudden Stop’

<table>
<thead>
<tr>
<th></th>
<th>2007-08 (April-March)</th>
<th>2008-09 (April-March)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Net Portfolio Inflow</strong></td>
<td>29.6</td>
<td>(-) 14</td>
</tr>
<tr>
<td><strong>Banking Capital</strong> (excluding non-resident deposits)</td>
<td>11.6</td>
<td>(-) 7.7</td>
</tr>
<tr>
<td><strong>Short-term Trade Credit</strong></td>
<td>17.2</td>
<td>(-) 5.8</td>
</tr>
</tbody>
</table>

*Source: RBI Website: www.rbi.org.in*

Use CVaR risk constraints to mitigate impacts. A CEO objective.
Liability dollarization in India, though low, has been increasing in recent years.

Indian banking system witnessed high credit growth rates in the years preceding the global financial crisis.
Multi-dimensional Risk Management

Mapping to Multi-Risk

<table>
<thead>
<tr>
<th>CB Strategic Objectives</th>
<th>Direct impact</th>
<th>Risk Limit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Price Stability 46%</td>
<td>Valuation losses</td>
<td>Opt net ALM in composite</td>
</tr>
<tr>
<td>More Complex Objectives 27%</td>
<td>Net op losses</td>
<td>LL on reserves in $ wrt GDP</td>
</tr>
<tr>
<td>Preserve External Value of Currency 13%</td>
<td>Credit risk events</td>
<td>LL on NFA/(NFA+NDA)</td>
</tr>
<tr>
<td>Efficient Payment Mechanism 6%</td>
<td>Systemic sudden stops</td>
<td>UL on % fall in $</td>
</tr>
<tr>
<td>Purchasing Power of Domestic Currency 4%</td>
<td>Interest rate shocks</td>
<td>M-t-M ≥ Exp-%comp</td>
</tr>
<tr>
<td>Guide Sound Banking Operations 2%</td>
<td>Inflation surge</td>
<td>LL on liquidity loss</td>
</tr>
<tr>
<td>Monetary stability 2%</td>
<td>Reserves + or -</td>
<td>NFA ≥ net ex 1 yr debt</td>
</tr>
<tr>
<td>Source: Davies and Green, 2010</td>
<td>Currency intervention</td>
<td>Net ex 1 yr debt/reserves ≤ L</td>
</tr>
<tr>
<td></td>
<td>Contingent liabilities</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Liquidity crises</td>
<td></td>
</tr>
</tbody>
</table>

Direct impact:
- Valuation losses
- Net op losses
- Credit risk events
- Systemic sudden stops
- Interest rate shocks
- Inflation surge
- Reserves + or -
- Currency intervention
- Contingent liabilities
- Liquidity crises

Risk Limit:
- Opt net ALM in composite
- LL on reserves in $ wrt GDP
- LL on NFA/(NFA+NDA)
- UL on % fall in $
- M-t-M ≥ Exp-%comp
- LL on liquidity loss
- NFA ≥ net ex 1 yr debt
- Net ex 1 yr debt/reserves ≤ L

Impact on balance sheet variables
RBI Tree

Mean-reverting branching tree

RBI Application

- 7 risk constraints over 3 periods = 21!
- 27 factors estimated with dependencies
- Smart tree

Factors on Tree (prices)
- Australia money market fund
- Cash in Euro, Sterling, USD, Yen
- Short bonds in Euro, Sterling, USD, Yen
- Long bonds in Euro, Sterling, USD, Yen
- Corporate bonds in Euro, Sterling, USD, Yen
- CB and BIS deposits (2)
- Exchange rates (3)
- External debt by residual maturity
- Total External debt
- Net domestic assets
- Liquidity requirements
- GDP
Communicating institutional strategic planning with strategic risk management.

It’s all clear now!

I talk CEO “strategic speak.”

I can convert that to analytics and back using DSP

Reducing chances of miscommunication!
### Table 6: Risk Constraints

<table>
<thead>
<tr>
<th>Constraint Shortfall Item</th>
<th>16-Jan-2010</th>
<th>16-Jan-2012</th>
<th>16-Jan-2015</th>
</tr>
</thead>
<tbody>
<tr>
<td>(1) US$ Billion 200 times GDP growth: shortfall expectation is 5% below expected with a 98% confidence level</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected Value of growth</td>
<td>208.15</td>
<td>238.72</td>
<td>298.74</td>
</tr>
<tr>
<td>Probability of a shortfall</td>
<td>0.35%</td>
<td>0.35%</td>
<td>0.43%</td>
</tr>
<tr>
<td>CVaR constraint value</td>
<td>197.74</td>
<td>226.31</td>
<td>283.81</td>
</tr>
<tr>
<td>Annualized marginal return of 1% change in confidence</td>
<td>0.0%</td>
<td>0.0%</td>
<td>0.0%</td>
</tr>
<tr>
<td>(2) Ratio of NFA/(NFA+NDA): shortfall expectation is 10% below expected with a 95% confidence for a 50% ratio</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected value of NFA in US$ billion</td>
<td>247.37</td>
<td>284.92</td>
<td>361.08</td>
</tr>
<tr>
<td>Probability of a shortfall</td>
<td>0.81%</td>
<td>0.73%</td>
<td>0.26%</td>
</tr>
<tr>
<td>CVaR constraint value</td>
<td>222.63</td>
<td>256.43</td>
<td>324.97</td>
</tr>
<tr>
<td>Annualized marginal return of 1% change in confidence</td>
<td>0.027%</td>
<td>0.000007%</td>
<td>0.002%</td>
</tr>
<tr>
<td>(3) Liquidity at risk- Liquid assets less requirements: shortfall expectation is 5% below at a 99% confidence</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Expected liquid assets in US$ billion</td>
<td>137.28</td>
<td>207.47</td>
<td>317.40</td>
</tr>
<tr>
<td>Probability of a shortfall</td>
<td>0.65%</td>
<td>5.01%</td>
<td>0.45%</td>
</tr>
<tr>
<td>CVaR constraint value</td>
<td>130.42</td>
<td>197.09</td>
<td>301.55</td>
</tr>
<tr>
<td>Annualized marginal return of 1% change in confidence</td>
<td>0.0%</td>
<td>0.004%</td>
<td>0.0%</td>
</tr>
</tbody>
</table>
Histogram of shortfall in ratio of NFA/(NFA+NDA) for 2015

50% ratio constraint
**Sample Constraints**

**Market limit loss in basket currency: expected less portfolio**

- **2010 binding**
- **2012 binding**
- **2015 binding**

*With 95% confidence expected shortfall < 10% expected reserves in basket currency*
### Statistics for Limit Shortfall Below Expected Value in Basket Currency

<table>
<thead>
<tr>
<th>Item</th>
<th>16-Jan 2009</th>
<th>16-Jan 2010</th>
<th>16-Jan 2012</th>
<th>16-Jan 2015</th>
</tr>
</thead>
</table>
| **Requirement:** At the 95% confidence level the shortfall below the expected value in the expect should not be more than 10%**  
Shortfalls are amounts by which this requirement is unmet |             |             |             |             |
| Expected portfolio value in basket              | 237.9       | 241.4       | 273.3       | 347.4       |
| Expected shortfall values                        |             | 7.2         | 10.3        | 19.9        |
| Probability (%) of a shortfall                   |             | 41.4        | 51.5        | 53.1        |
| Target shortfall CVaR at 95% confidence          |             | 24.1        | 27.3        | 34.7        |
| Actual shortfall CVaR at 95%                    |             | 24.1        | 27.3        | 34.7        |
| VaR at 95%                                      |             | -28.3       | -10.9       | 2.6         |
| % worst shortfall                                |             | 65.6        | 72.7        | 83.3        |
| Constraint intensity (marginal)                 |             | 2.5         | 3.1         | 14.9        |
| Corresponding VaR to CVaR                       |             | 5.9         | 19.6        | 34.6        |
Initial portfolio rollover analysis

Rollover actual 25.00% -- Rollover limit 25.00%

Denominated in currency of origin

<table>
<thead>
<tr>
<th>Instrument</th>
<th>Sell</th>
<th>Buy</th>
<th>Holdings</th>
</tr>
</thead>
<tbody>
<tr>
<td>AUD Cash Total Return Index</td>
<td>10.00</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>BIS and Central Banks Deposits</td>
<td>37.26</td>
<td>0.00</td>
<td>65.29</td>
</tr>
<tr>
<td>USD Cash</td>
<td>0.00</td>
<td>20.00</td>
<td>29.13</td>
</tr>
<tr>
<td>LEHMAN GLOBAL: US TREASURY 1-3 YR</td>
<td>4.62</td>
<td>0.00</td>
<td>50.16</td>
</tr>
<tr>
<td>LEHMAN US AGG A+ 5+ YR</td>
<td>0.00</td>
<td>0.00</td>
<td>18.26</td>
</tr>
<tr>
<td>US Corporate Bonds</td>
<td>0.00</td>
<td>9.69</td>
<td>18.82</td>
</tr>
<tr>
<td>Euro Cash</td>
<td>0.00</td>
<td>15.31</td>
<td>17.46</td>
</tr>
<tr>
<td>LEHMAN EURO-AGG. 1 - 3 YEAR (E)</td>
<td>2.62</td>
<td>0.00</td>
<td>10.28</td>
</tr>
<tr>
<td>LEHMAN EURO-AGG. 10+ YEAR (E)</td>
<td>0.00</td>
<td>0.00</td>
<td>4.30</td>
</tr>
<tr>
<td>Euro Corporate Bonds</td>
<td>2.15</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>UK Cash</td>
<td>0.00</td>
<td>2.41</td>
<td>2.89</td>
</tr>
<tr>
<td>LEHMAN GLOBAL: UK 1 - 3 YEAR</td>
<td>0.00</td>
<td>0.00</td>
<td>2.89</td>
</tr>
<tr>
<td>LEHMAN GLOBAL: UK LONG</td>
<td>0.00</td>
<td>0.61</td>
<td>1.57</td>
</tr>
<tr>
<td>UK Corporate Bonds</td>
<td>0.00</td>
<td>0.00</td>
<td>0.48</td>
</tr>
<tr>
<td>Yen Cash</td>
<td>0.00</td>
<td>563.01</td>
<td>625.57</td>
</tr>
<tr>
<td>LEHMAN GLOBAL: JAPAN 1-3Y</td>
<td>375.35</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>LEHMAN GLOBAL: JAPAN LONG</td>
<td>125.12</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>Yen Corporate Bonds</td>
<td>0.00</td>
<td>0.00</td>
<td>62.56</td>
</tr>
</tbody>
</table>
Enables CEO strategic speak to be formulated with risks and results communicated back

- tailors strategic objectives and constraints to each institution
- long-term performance over short-term gains
- controls and integrates several risks simultaneously
- incorporates extreme movements and non-normal processes
- integrates a structured mathematical framework with collective (recommendations, theories, and implied prices) and individual wisdom
- dynamic with assets, liabilities, and derivatives
- allows processes to change over time and level as regimes change
- allows you to shape the risk profiles of multiple integrated risks simultaneously
Mitigate the next crisis!

Use a paradigm (technology) that addresses all the failure factors.

Use DSP!
References


