



## **Yet Another New Paradigm Multi-dimensional Strategic Risk Management**

Prof. Dr. Jerome L. Kreuser

The Riskontrol Group GmbH

Bern, Switzerland      <http://riskontroller.com>

[kreuser@riskontroller.com](mailto:kreuser@riskontroller.com)

Northfield's 24<sup>th</sup> Annual Research Conference

June 24-26, 2011



## 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.**





# Risk Management Failures

A famous professor named Rene M. Stulz listed the risk management failures and remedies in the financial crisis.



**Our Focus**

### Failures

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

### 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

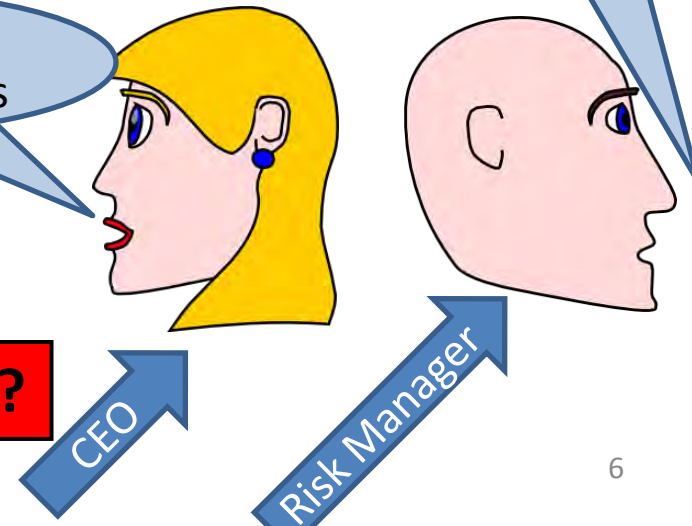
RisKontroller "Shape the Future"™ Technology

## 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)

ROE, mission, strategies, targets

VaR, utility, preference, variance, ...



**Communication: Whose responsibility is it?**



## CEO speak

### 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

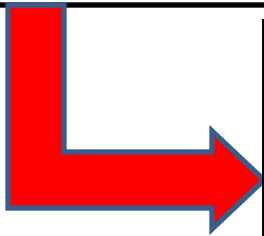


## Paradigm Properties

RisKontroller "Shape the Future"™ Technology

### 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**





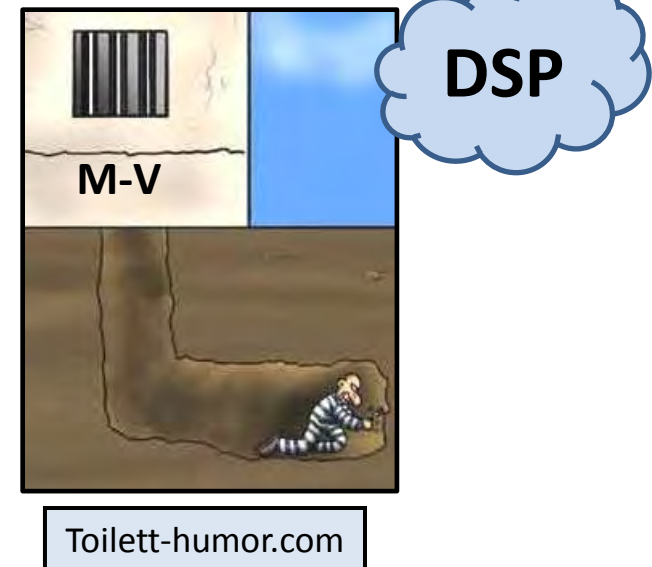
# DSP Paradigm

RisKontroller "Shape the Future"™ Technology

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





# Exploding Myths

RisKontroller "Shape the Future"™ Technology

- 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!



# The Foundation

## ▪ 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

Estimations of these are very useful and flexible.

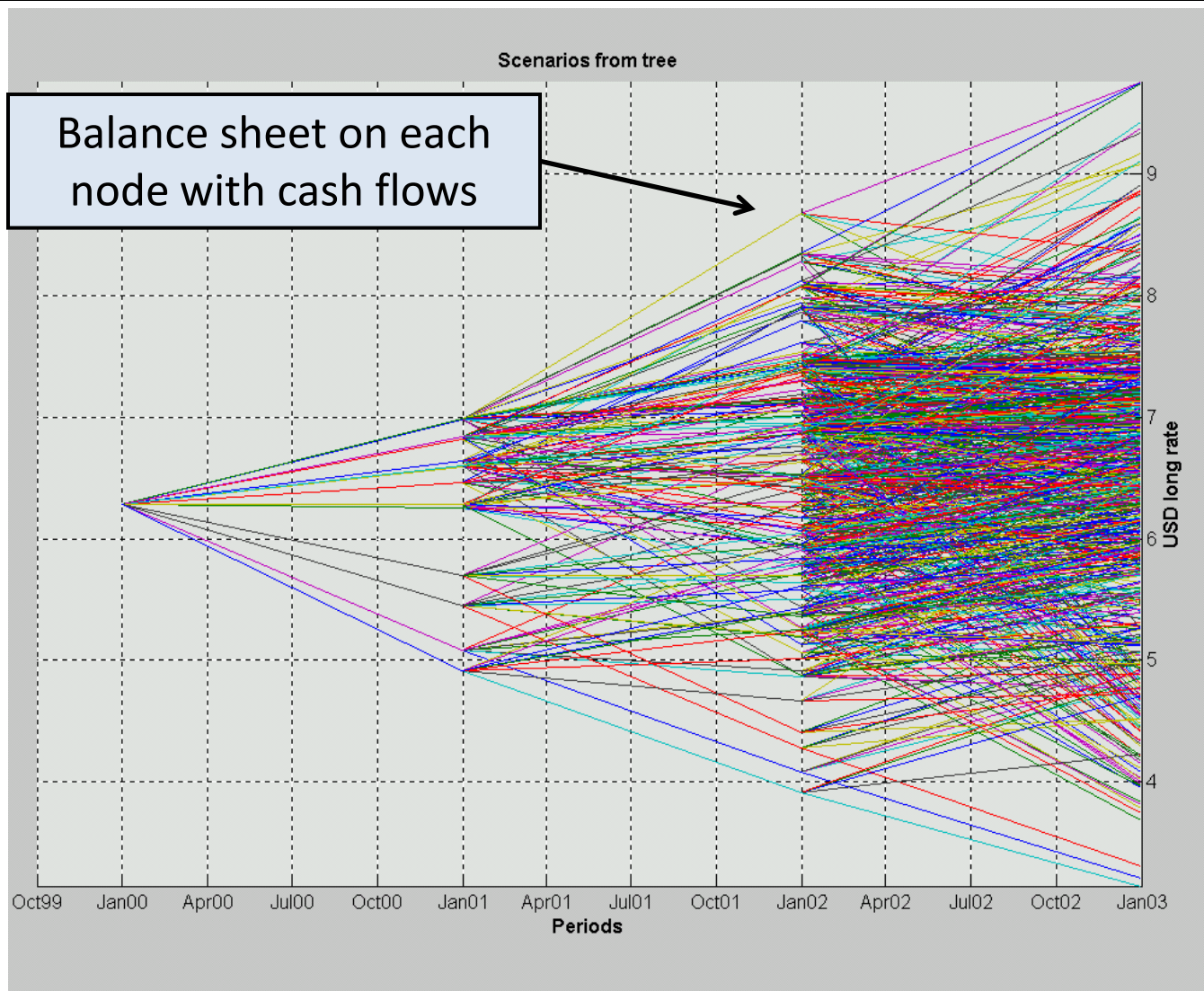


The econo-physicist J. L. McCauley says these are the "... best tractable approximation to market dynamics."

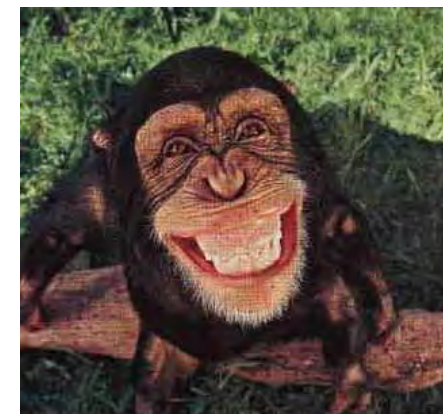


## Trees and Factors on Tree

RisKontroller "Shape the Future"™ Technology



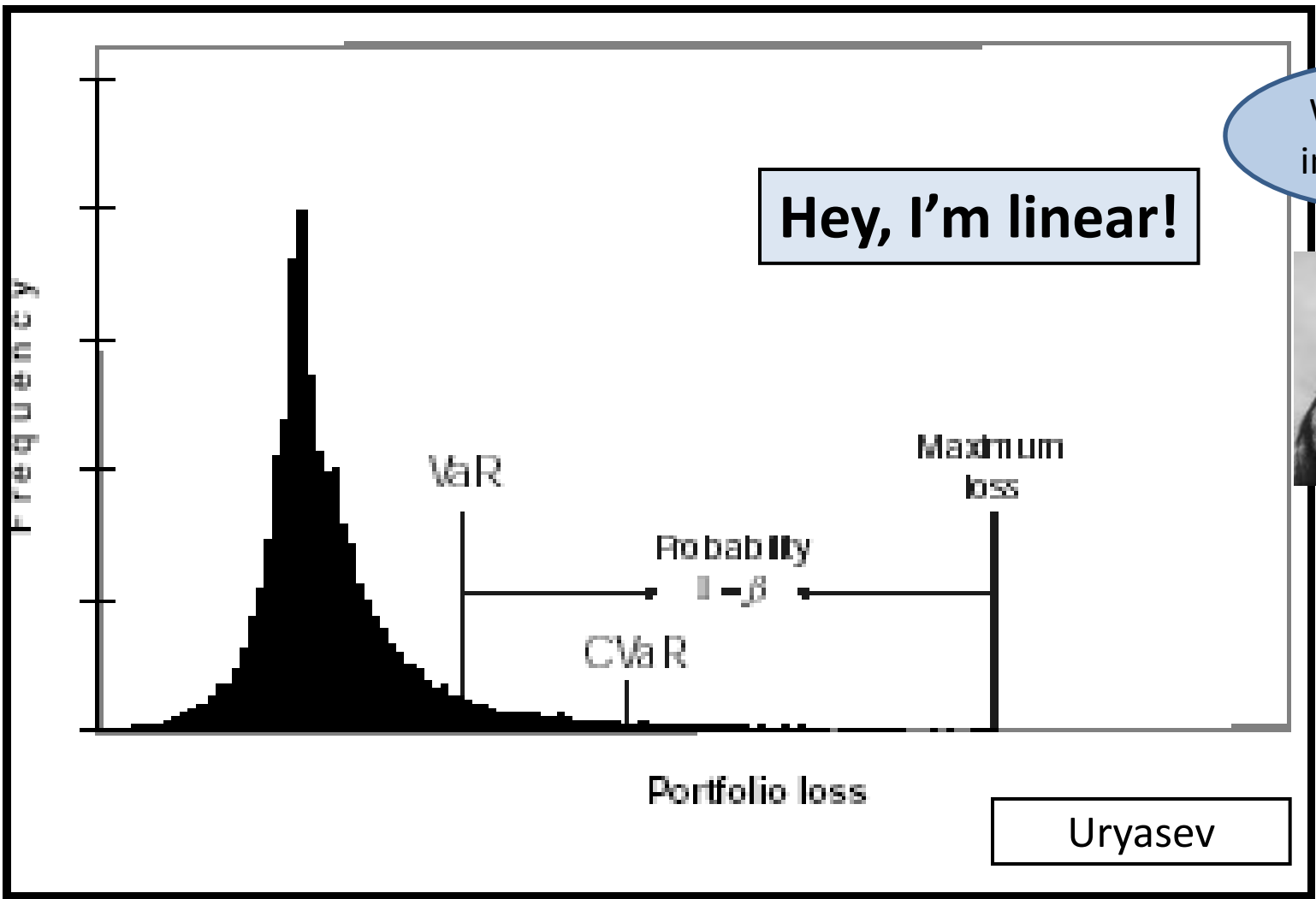
Use previous to generate a sparse tree with variable probability branches.





# CVaR Risk Constraint

RisKontroller "Shape the Future"™ Technology



Why is that important??



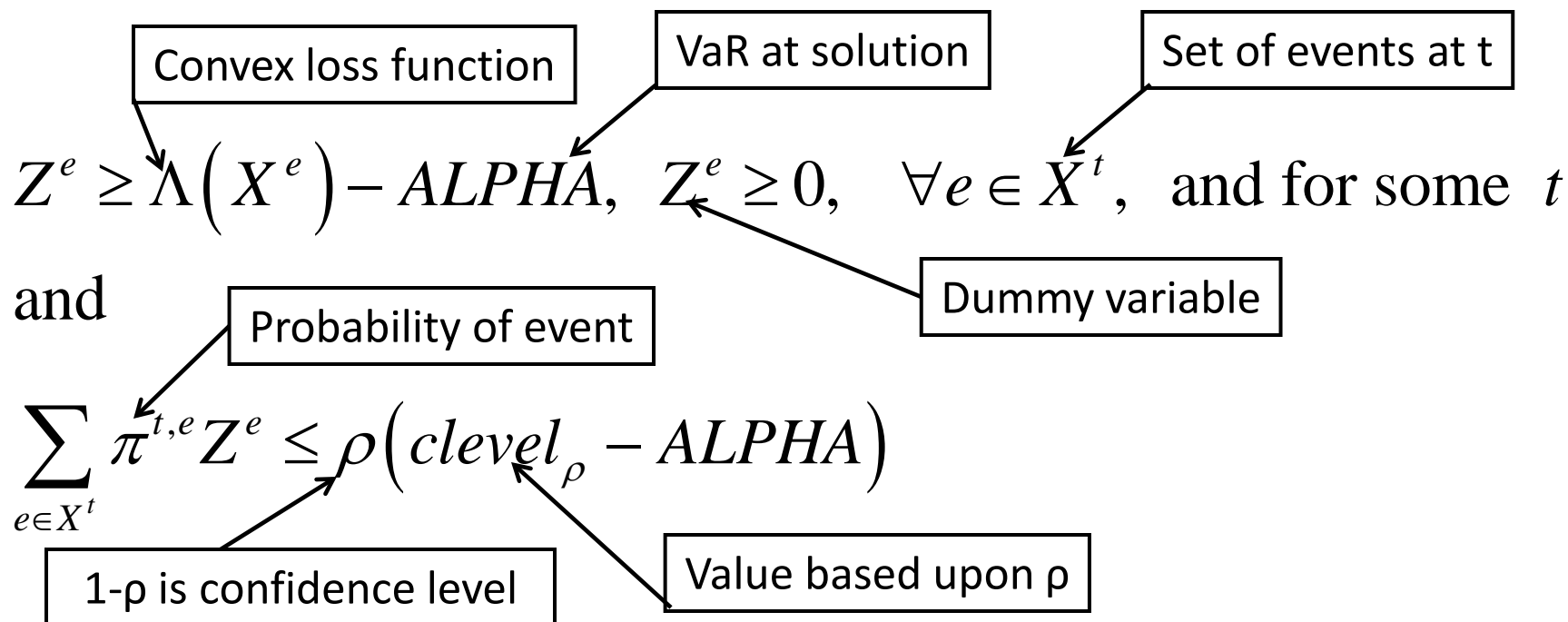
Uryasev



## CVaR Constraint Formulation

RisKontroller "Shape the Future"™ Technology

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.





# Model and Results

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



# Failure Factor Remedies

RisKontroller "Shape the Future"™ Technology

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

**And communications**





## Application to India RBI

### 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.



## RBI

# 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



## RBI

# 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



## 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



## CEO Rationale

### Rationale for Choice of Parameters and Risk Factors (2)

- 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.



# Sudden Stops

<b>Capital Flow items associated with 'Sudden Stop'</b>	<b>2007-08 (April-March)</b>	<b>2008-09 (April-March)</b>
<b>Net Portfolio Inflow</b>	<b>29.6</b>	<b>(-) 14</b>
<b>Banking Capital (excluding non-resident deposits)</b>	<b>11.6</b>	<b>(-) 7.7</b>
<b>Short-term Trade Credit</b>	<b>17.2</b>	<b>(-) 5.8</b>

Use CVaR risk constraints to mitigate impacts.

A CEO objective.

Source: RBI Website: [www.rbi.org.in](http://www.rbi.org.in)





## CEO Rationale

### Rationale for Choice of Parameters and Risk Factors (3)

- 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.



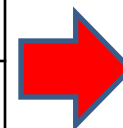
## Mapping to Multi-Risk

RisKontroller "Shape the Future"™ Technology

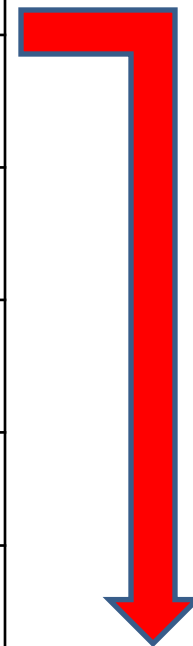
CB Strategic Objectives
Price Stability 46%
More Complex Objectives 27%
Preserve External Value of Currency 13%
Efficient Payment Mechanism 6%
Purchasing Power of Domestic Currency 4%
Guide Sound Banking Operations 2%
Monetary stability 2%
Source: Davies and Green, 2010



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 $\geq$ Exp - %comp
LL on liquidity loss
NFA $\geq$ net ex 1 yr debt
Net ex 1 yr debt/reserves $\leq$ L

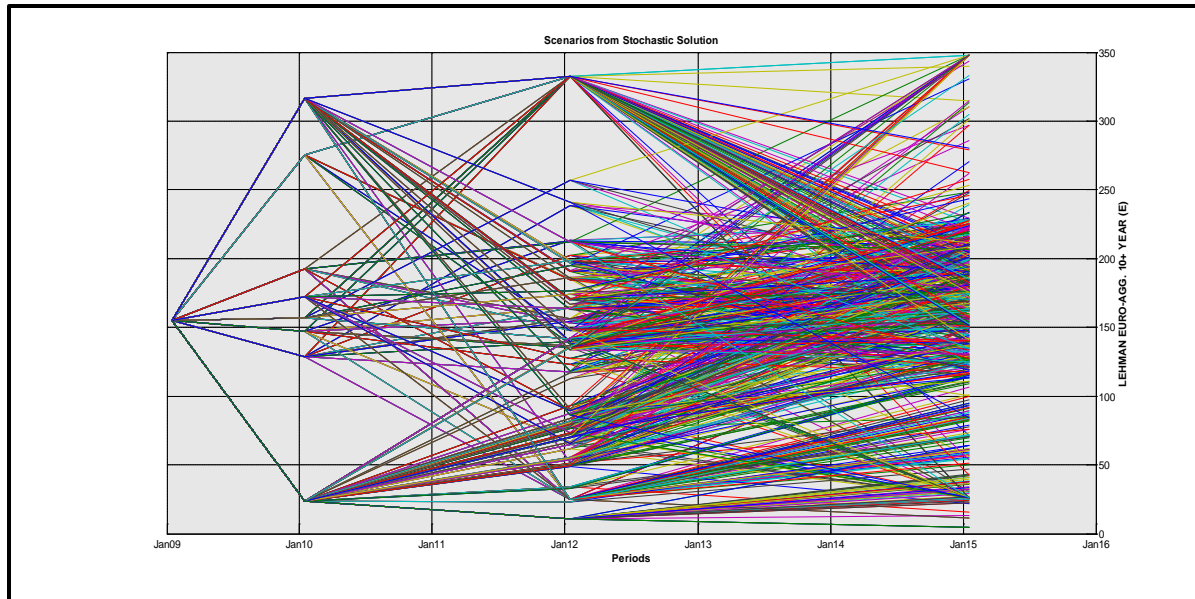


Impact on balance sheet variables



## RBI Tree

### Mean-reverting branching 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

### RBI Application

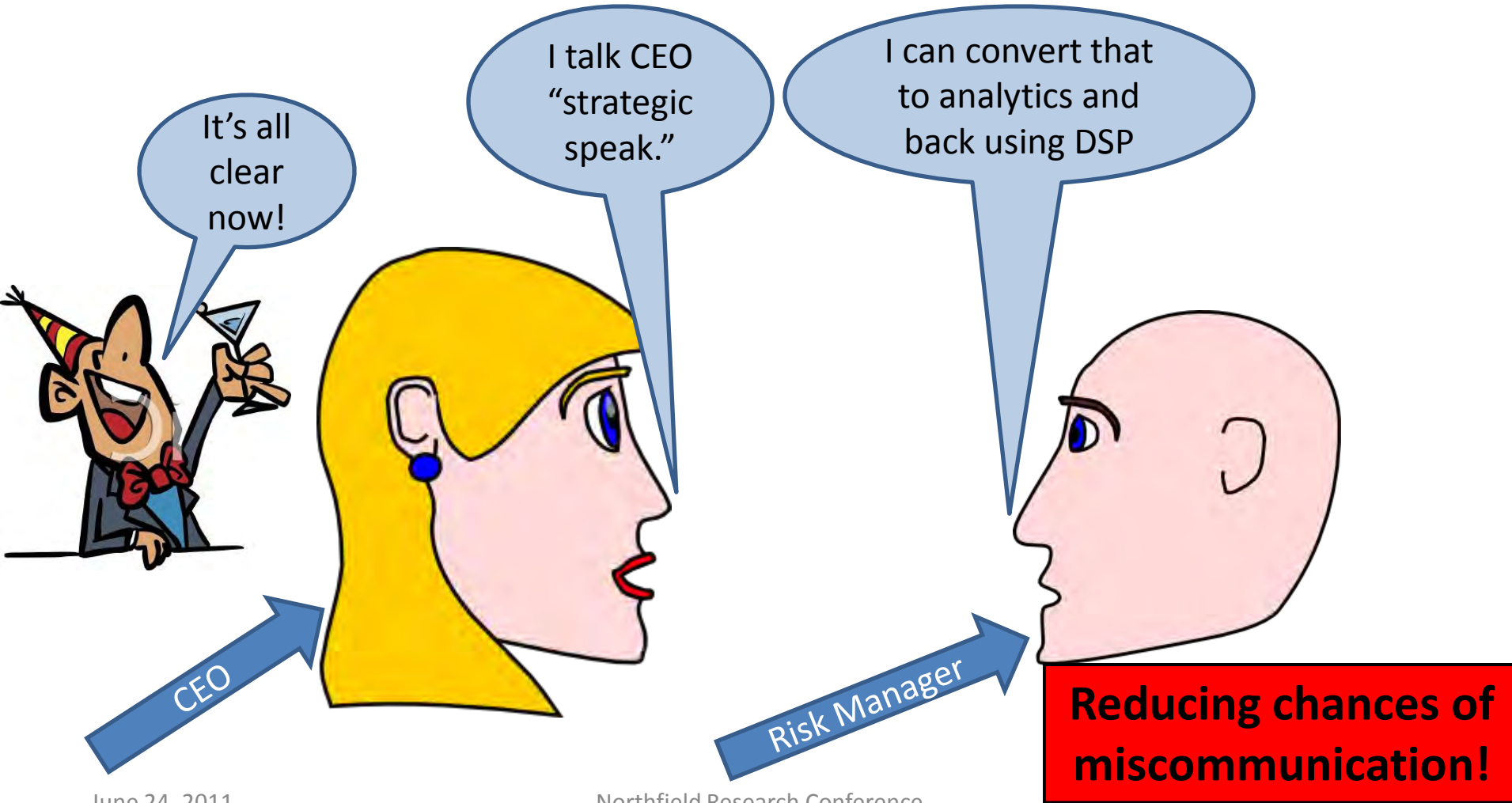
- 7 risk constraints over 3 periods = 21!
- 27 factors estimated with dependencies
- Smart tree



# Communicating

RisKontroller "Shape the Future"™ Technology

Communicating institutional strategic planning with strategic risk management.





# Sample Results

Table 6: Risk Constraints

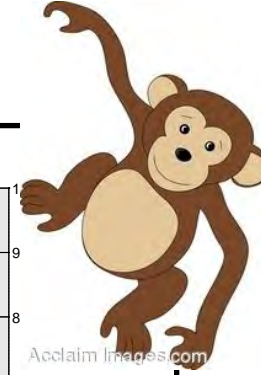
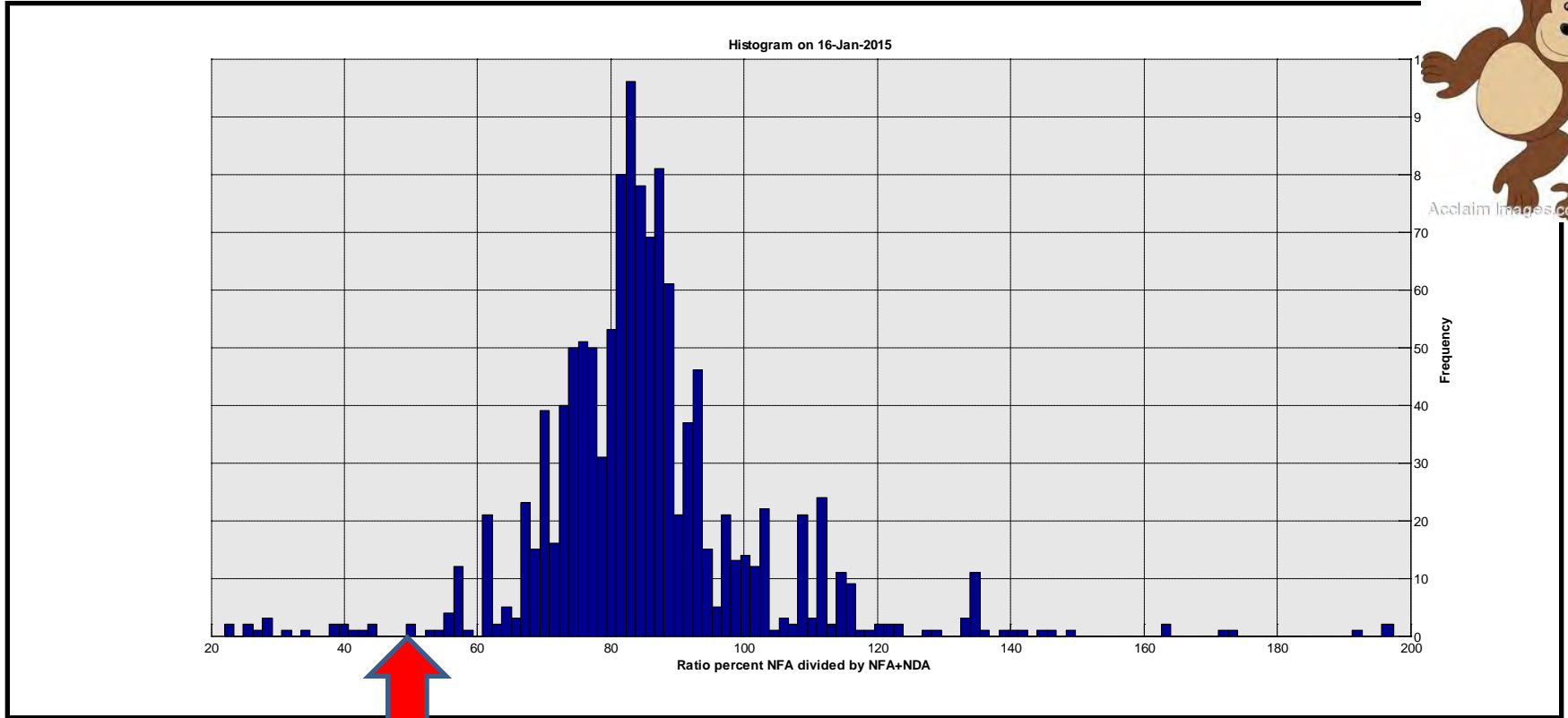
Constraint Shortfall Item	16-Jan-2010	16-Jan-2012	16-Jan-2015
<b>(1) US\$ Billion 200 times GDP growth: shortfall expectation is 5% below expected with a 98% confidence level</b>			
Expected Value of growth	208.15	238.72	298.74
Probability of a shortfall	0.35%	0.35%	0.43%
CVaR constraint value	197.74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



# Sample Uncertainty

RisKontroller "Shape the Future"™ Technology

### Histogram of shortfall in ratio of $NFA/(NFA+NDA)$ for 2015



**50% ratio constraint**

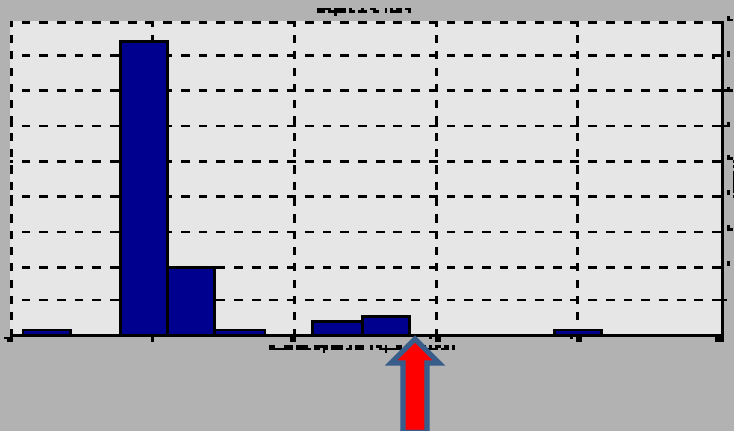


### Sample Constraints

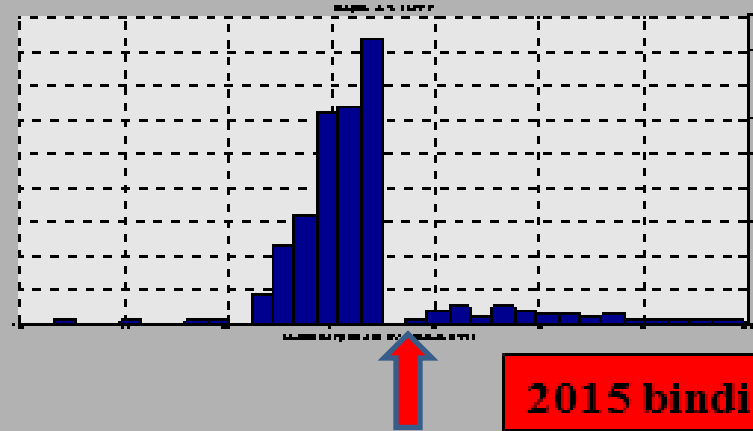
RisKontroller "Shape the Future"™ Technology

Market limit loss in basket currency: expected less portfolio

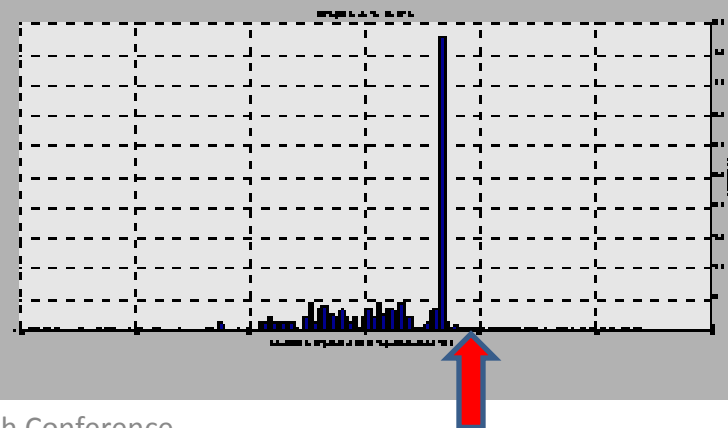
**2010 binding**



**2012 binding**



**2015 binding**



With 95% confidence expected  
shortfall < 10% expected  
reserves in basket currency



## Sample Output

### Statistics for Limit Shortfall Below Expected Value in Basket Currency

Item	16-Jan 2009	16-Jan 2010	16-Jan 2012	16-Jan 2015
<p><b>Requirement: At the 95% confidence level the shortfall below the expected value in the expect should not be more than 10%</b></p> <p><b>Shortfalls are amounts by which this requirement is unmet</b></p>				
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





## Sample Output

RisKontroller "Shape the Future"™ Technology

Initial portfolio rollover analysis

Rollover actual 25.00% -- Rollover limit 25.00%

Denominated in currency of origin

Instrument	Sell	Buy	Holdings
AUD Cash Total Return Index	10.00	0.00	0.00
BIS and Central Banks Deposits	37.26	0.00	65.29
USD Cash	0.00	20.00	29.13
LEHMAN GLOBAL: US TREASURY 1-3 YR	4.62	0.00	50.16
LEHMAN US AGG A+ 5+ YR	0.00	0.00	18.26
US Corporate Bonds	0.00	9.69	18.82
Euro Cash	0.00	15.31	17.46
LEHMAN EURO-AGG. 1 - 3 YEAR (E)	2.62	0.00	10.28
LEHMAN EURO-AGG. 10+ YEAR (E)	0.00	0.00	4.30
Euro Corporate Bonds	2.15	0.00	0.00
UK Cash	0.00	2.41	2.89
LEHMAN GLOBAL: UK 1 - 3 YEAR	0.00	0.00	2.89
LEHMAN GLOBAL: UK LONG	0.00	0.61	1.57
UK Corporate Bonds	0.00	0.00	0.48
Yen Cash	0.00	563.01	625.57
LEHMAN GLOBAL: JAPAN 1-3Y	375.35	0.00	0.00
LEHMAN GLOBAL: JAPAN LONG	125.12	0.00	0.00
Yen Corporate Bonds	0.00	0.00	62.56



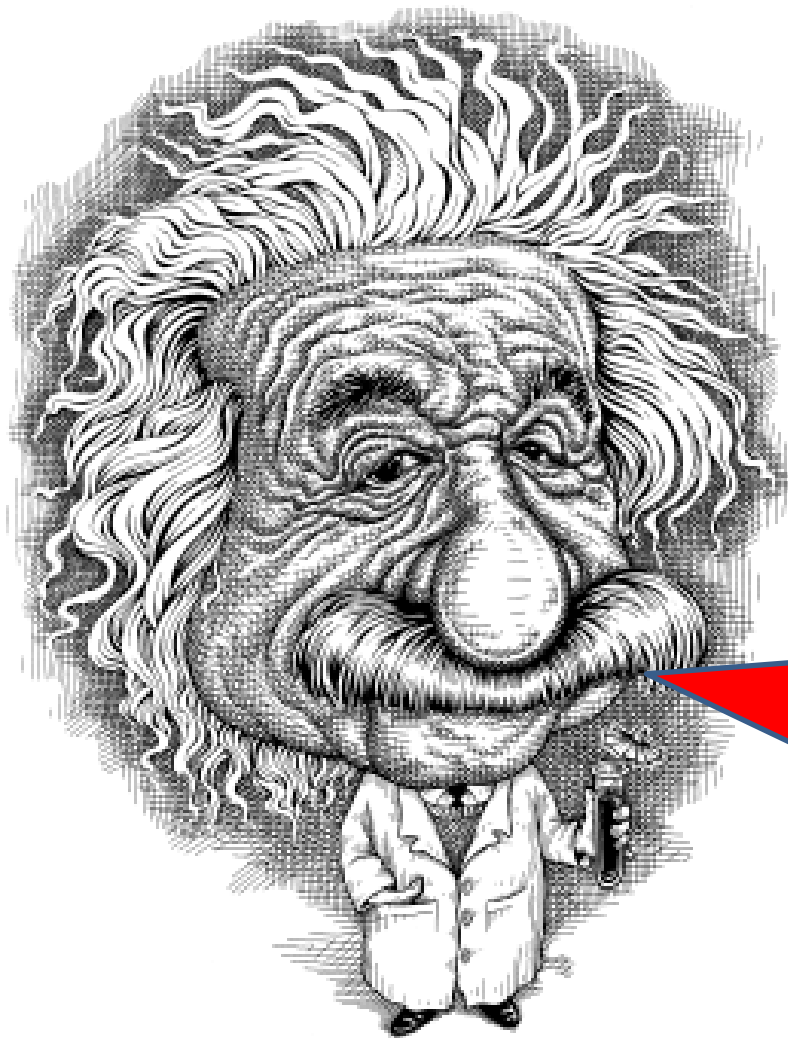
## The DSP Paradigm

- **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



# Prevent Problems

RisKontroller "Shape the Future"™ Technology



**'Intellectuals  
solve problems;  
geniuses  
prevent them'**  
Albert Einstein

© redmolotov.com


**Mitigate the next crisis!**

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

**Use DSP!**



## References

- Bhattacharya, Himadri; Jerome Kreuser, and Sivaprakasam Sivakumar (2010). "Stress testing central banks and beyond", Presented at the BIS/ECB/WB Meeting, November, in publication. 
- Bhattacharya, Himadri; Jerome Kreuser, and Sivaprakasam Sivakumar (2009). "A Sovereign Asset-Liability Framework with Multiple Risk Factors for External Reserves Management – Reserve Bank of India", Presented at the BIS/ECB/WB Meeting, in publication.
- Claessens, Stijn and Jerome Kreuser (2008). "Strategic Investment and Risk Management for Sovereign Wealth Funds", BIS/ECB/WB Meeting November 2008, in *Central Bank Reserves and Sovereign wealth Management*, edited by Arjan B. Berkelaar, Joachim Coche, and Ken Nyholm, 2010, Palgrave MacMillan, Hampshire, England.
- Claessens, Stijn and Jerome Kreuser (2007) "Strategic foreign reserves risk management: Analytical framework", in *Financial Modeling*, Annals of Operations Research Volume 152: 79-113, Springer, Netherlands.
- Claessens, Stijn and Jerome Kreuser (2004). "A Framework for Strategic Foreign Reserves Risk Management," in *Risk Management for Central Bank Foreign Reserves*, European Central Bank Publication, Frankfurt am Main, May.
- Claessens, Stijn, Jerome Kreuser, and Roger J-B Wets (2000). "Strategic Risk Management for Developing Countries: The Colombia Case Study," Paper presented at the Second Inter-regional Debt Management Conference, UNCTAD, Geneva, April 3-5, 2000.
- Kreuser, Jerome L. (2002). "The rapid implementation of asset/liability models for sovereign risk management", in *Programming Languages and Systems in Computational Economics and Finance*, Kluwer Academic Publishers.