RISK MANAGEMENT WITH BENCHMARKING

WORKSHOP ON ASSET & LIABILITY MANAGEMENT – MIDRAND, SOUTH AFRICA

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national treasury

Department:
National Treasury
REPUBLIC OF SOUTH AFRICA

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- **Risk measures and mitigation strategies in South Africa**
  - Currency Risk
  - Liquidity & Refinancing Risk
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  - Interest Rate Risk
- **Qualitative & Risk Prioritisation Methodology**
- **Developments in risk benchmarks**

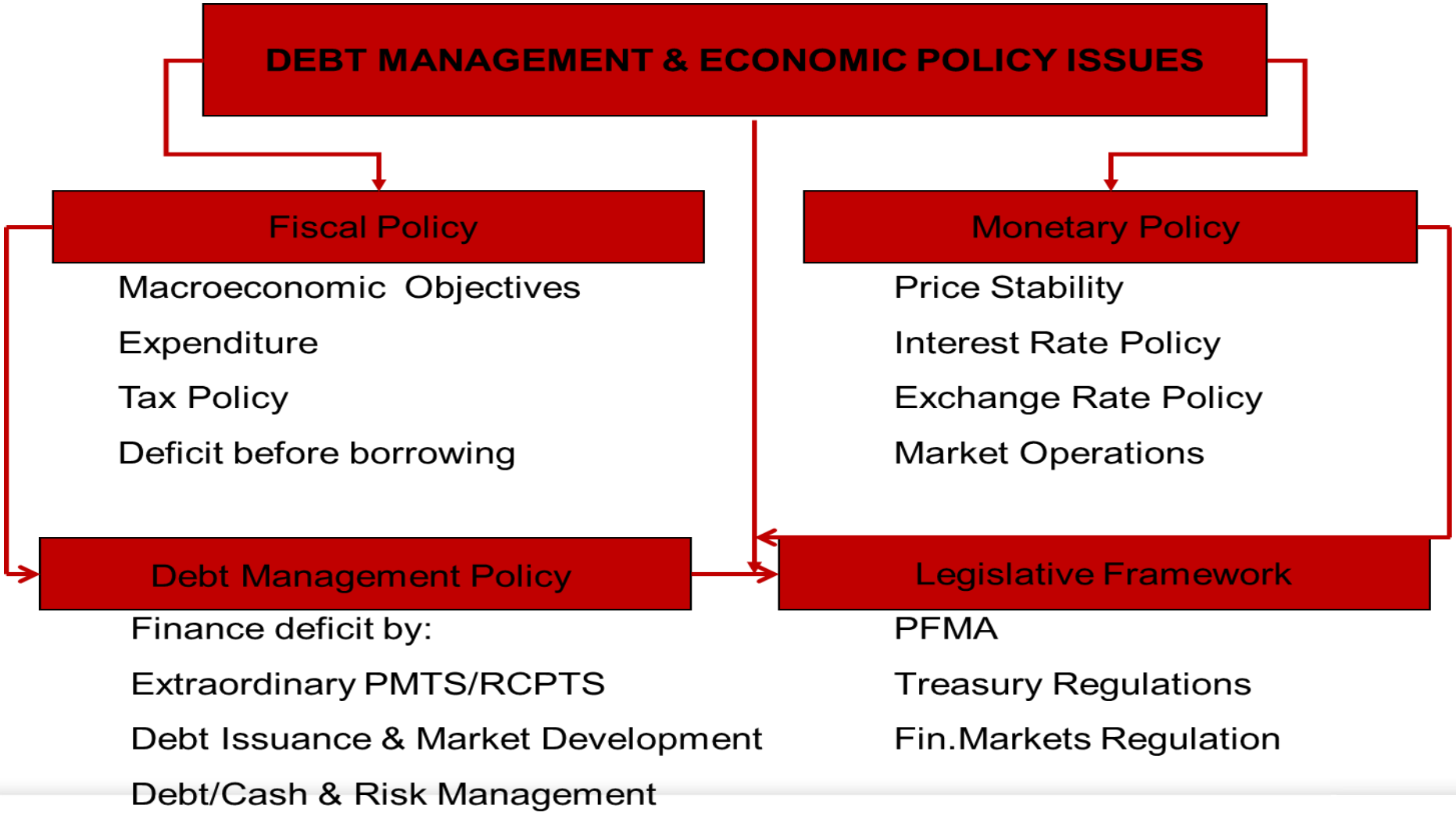
How may we define risk benchmarks?

- Advances in Risk Management of Government Debt, OECD, 2005:
  - Strategic benchmark as a tool to control risk
    - ✓ Requires government to specify its risk tolerance and portfolio preferences regarding the trade-off between expected cost and risk.
  - Optimal debt composition
    - ✓ Derived through assessing the relative impact of the risk and costs of various debt instruments on the probability of missing a well-defined stabilization target.
  - Key roles of strategic benchmark
    - ✓ They provide guidance on the management of costs and risk.
    - ✓ Define a framework for assessing portfolio performance in relation to cost and risk.

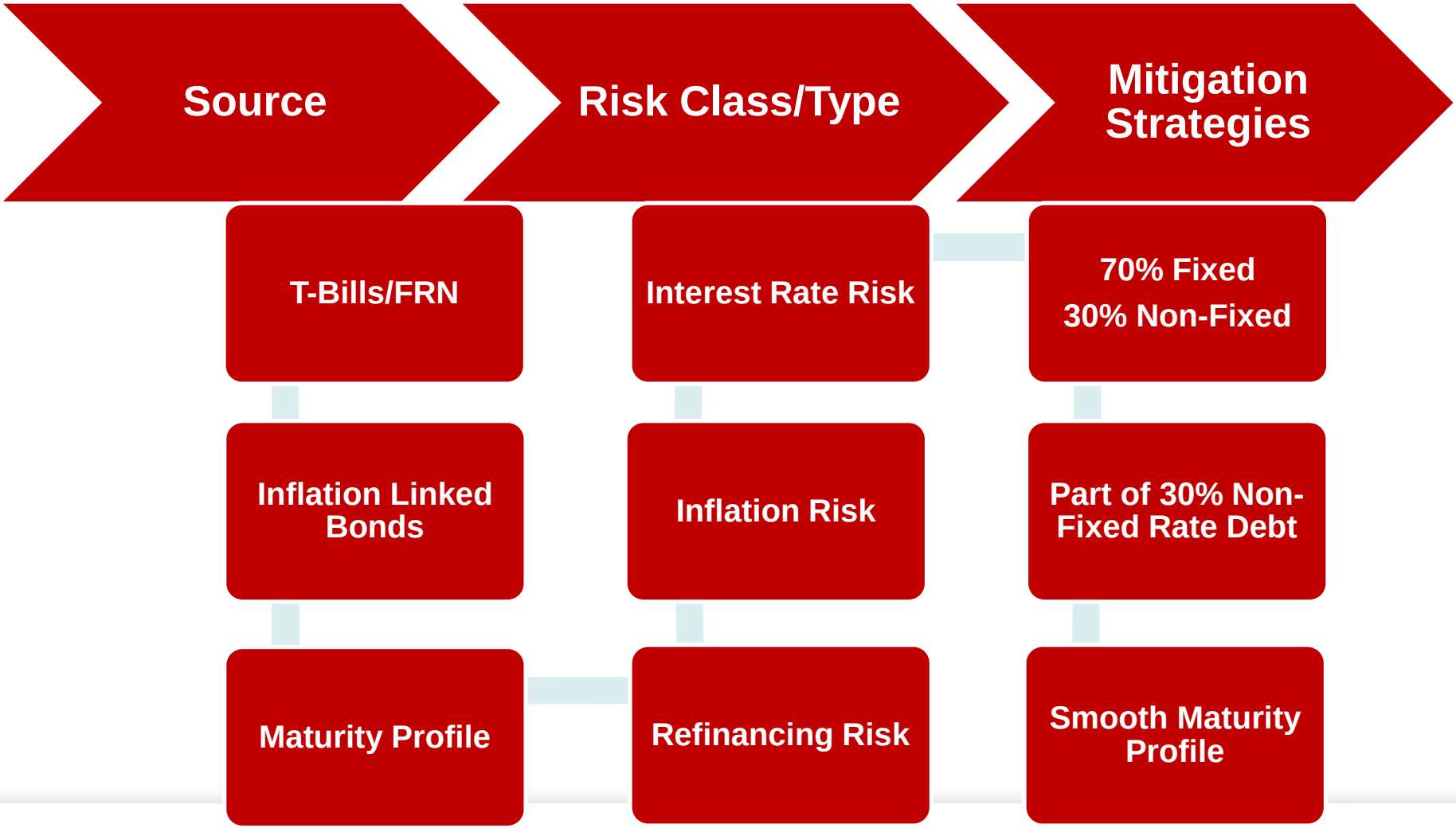
Other notable publications on risk benchmarks?

- Guidelines of Sound Practices in Public Debt Management, IMF/WB, 2001:
  - As may be inferred from the 4th Guideline – "*Debt Management Strategy"*
    - ✓ Risk benchmarks express the portfolio preference (debt structure) of Government in terms of maturity, interest rate and currency composition.
  - In terms of the 5th Guideline – "*Risk Management Framework*"
    - ✓ Risk benchmarks need to be flexible as to accommodate economic and financial market shocks.
  - Last/not least in terms of the 1st Guideline – "*Debt Management Objectives and Coordination"*
    - ✓ Risk benchmarks operationalize the primary objective of managing government debt taking into account the interaction between debt management, fiscal and monetary policies.

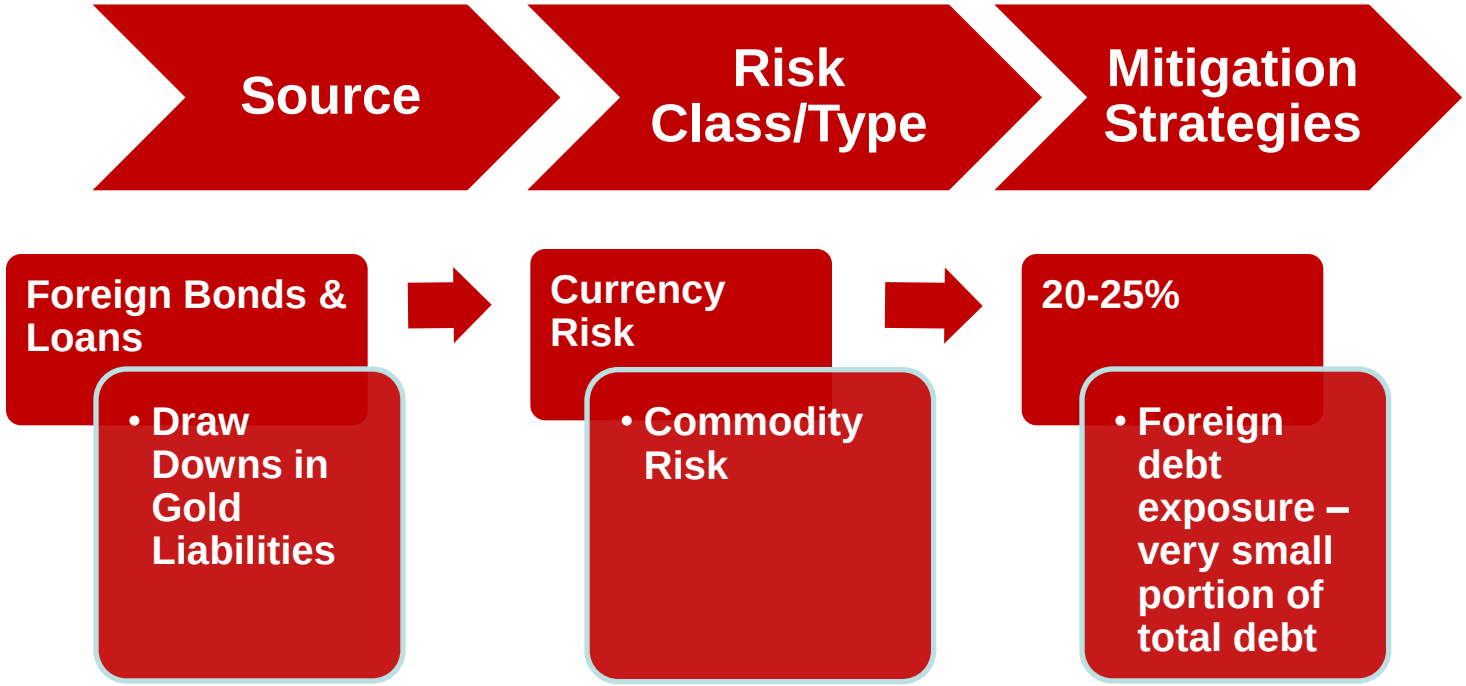
Strategic benchmarks & Policy linkages



Sources of Market Risk (Local Currency Debt)



Sources of Market Risk (Foreign Currency Debt)



Currency Risk Indicators

- **Portfolio Risk**
  - Foreign debt as a % of total debt
- **Debt Sustainability Risks**
  - Total foreign debt as % of GDP
  - Foreign currency debt/int. pmt as % of Tax revenue from exports
  - Current Account Deficit as % of GDP
  - Exchange rate volatility
  - Foreign currency liability as % of reserves

Currency Risk Techniques and Mitigation Strategies

- **Techniques**
  - Value at Risk
  - Cost at Risk
  - Probability Forecast Model
- **Mitigation Strategies**
  - 20% exposure to the risk factor with a permissible upward deviation of 5%

Example 1: Value@Risk – Foreign Currency Debt

Summary Statistics – June 2013

Measure of Central Tendency	USDZAR	EURZAR	GBPZAR	ZARJPY	SEKZAR
Average	9.47	12.38	14.55	10.44	1.44
STD	0.44	0.63	0.72	0.57	0.06
CV	4.65	5.09	4.95	5.46	4.17
Max	10.2	13.51	15.80	11.23	1.56
Min	9.44	11.60	13.61	9.44	1.37

Correlation Matrix – June 2013

Currency	USDZAR	EURZAR	GBPZAR	ZARJPY	SEKZAR
USDZAR	1.000				
EURZAR	0.979	1.000			
GBPZAR	0.972	0.995	1.000		
ZARJPY	-0.893	-0.918	-0.919	1.000	
SEKZAR	0.940	0.970	0.957	-0.926	1.000

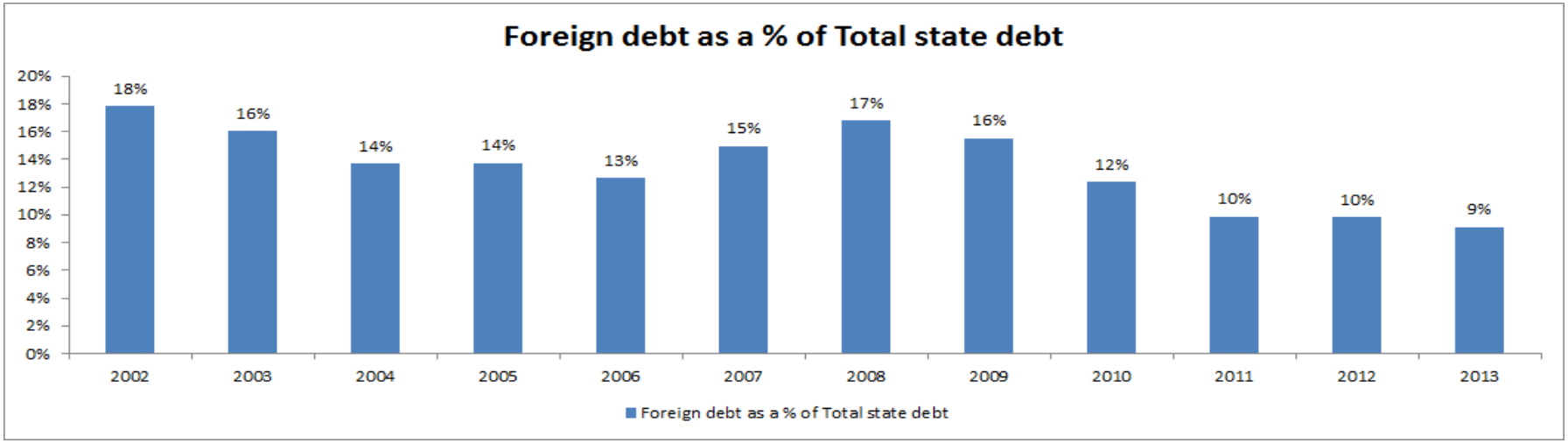
Value Position (Outstanding Foreign Currency Debt in USDZAR, EURZAR, ZARJPY)

Outstanding Amount		ZARJPY	USDZAR	EURZAR
Value of position		R 6,000,000,000	R 83,341,297,966	R 9,687,750,000

Value-at-Risk Amounts – June 2013

VaR Methods		ZARJPY	USDZAR	EURZAR
Var(5%)-T Distribution		R 149,257,179	R 1,564,854,397	R 169,007,402
DEAR		R 124,654,183	R 1,306,909,637	R 141,148,853
Monte Carlo		R 118,685,471	R 1,223,630,211	R 120,235,418

Example 2: share of foreign currency debt & Probability Forecast Distribution



USDZAR	Price Range	Probability (Percent)
July	9.42- 10.55	74.9
August	9.25- 10.81	75
September	9.08- 11.06	76.3
EURZAR	**Price Range**	**Probability (Percent)**
July	12.34- 13.68	72.4
August	12.12- 14.01	73.5
September	11.93- 14.32	74.9
GBPZAR	**Price Range**	**Probability (Percent)**
July	14.43-15.95	73.1
August	14.18- 16.32	74.9
September	13.98- 16.64	76.3
ZARJPY	**Price Range**	**Probability (Percent)**
July	9.26-10.72	71
August	8.95- 10.95	71.3
September	8.67- 11.13	71.6
ZARSEK	**Price Range**	**Probability (Percent)**
July	0.64- 0.70	72.7
August	0.63- 0.71	73.6
September	0.61- 0.72	74.7

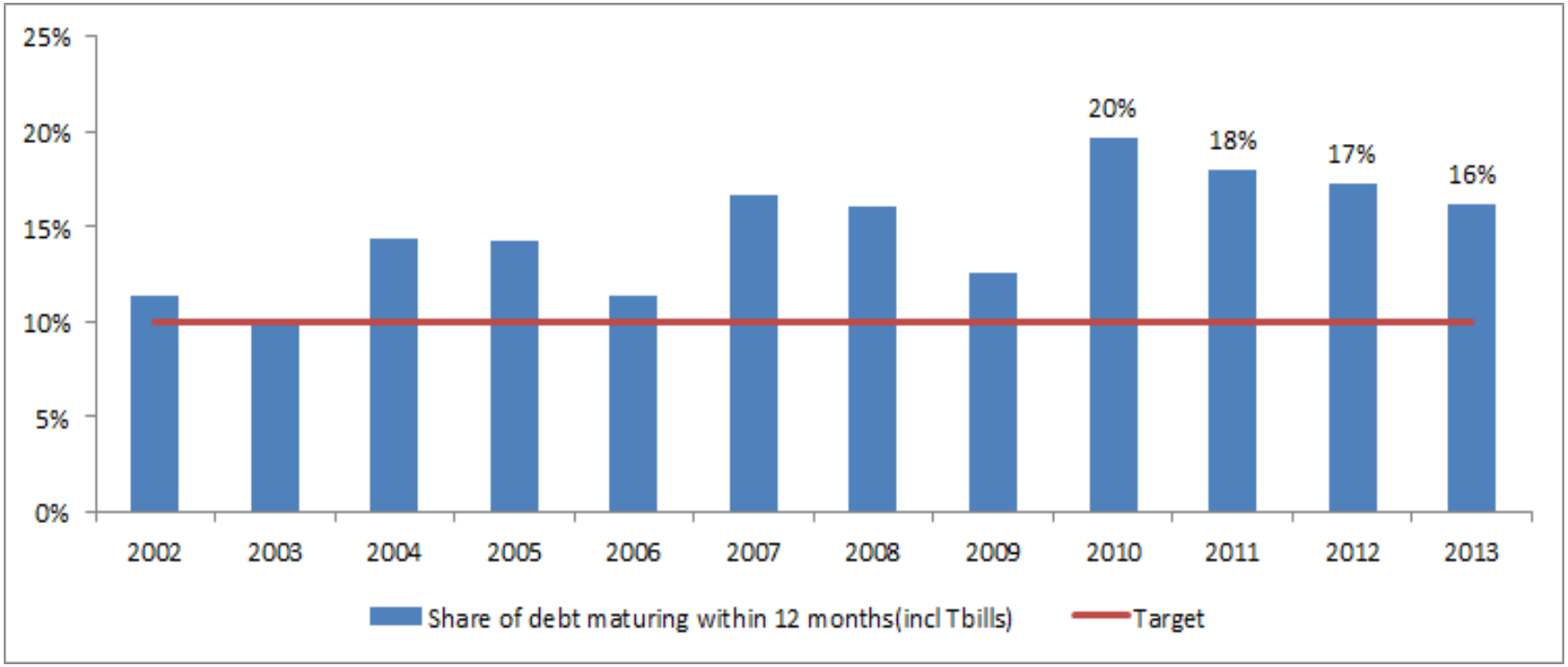
Refinancing Risk Indicators

- Share of debt maturing in 12 months

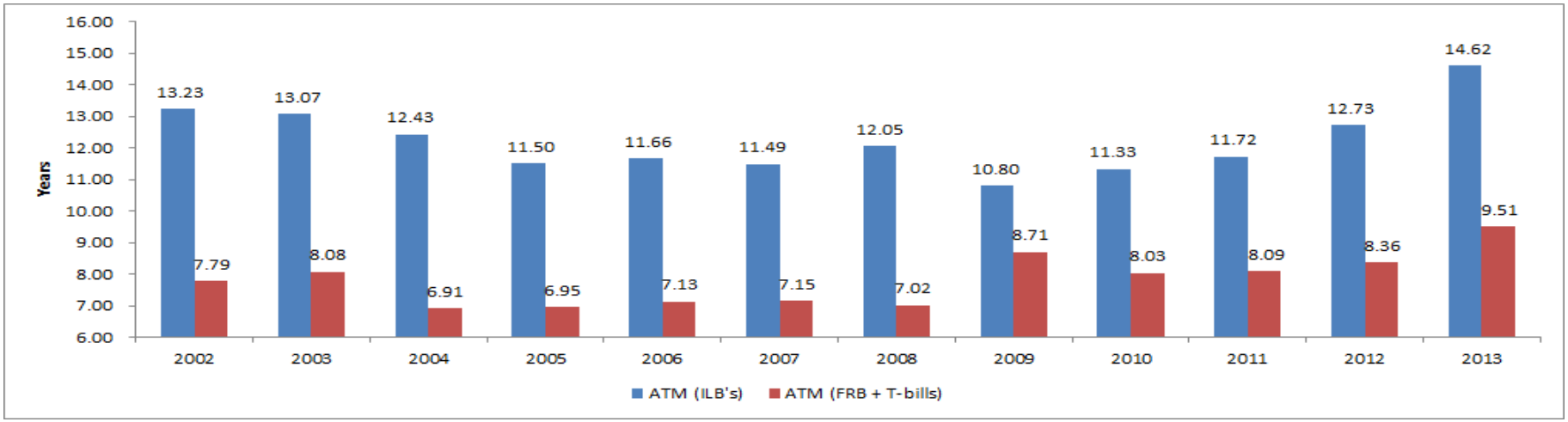
- Average Term to maturity
  - Historical ATM
  - Current portfolio ATM

- Smooth maturity profile

Example 1: Share of debt maturing in 12 months

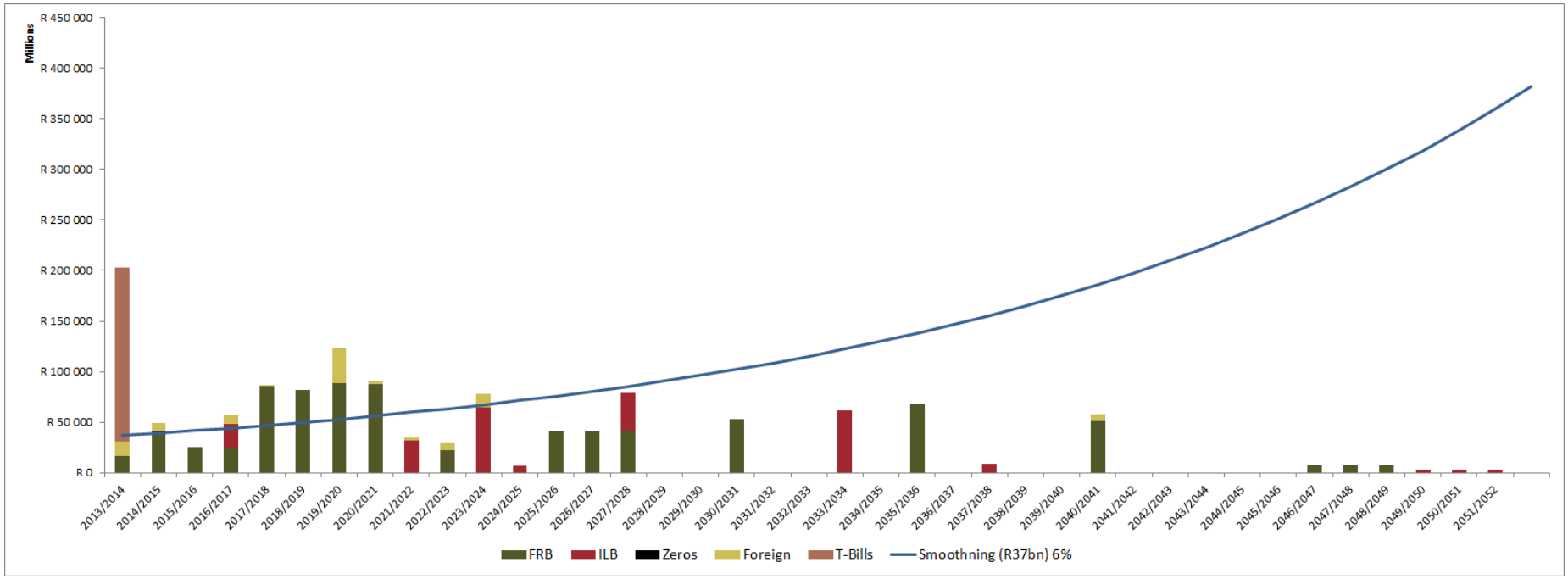


Example 2: historical and current portfolio ATM



	1 Week Ago	Amount 27 September 2013
Fixed rate bonds		
Average Term to Maturity (Years)	11.733	11.726
Modified Duration (Years)	6.323	6.288
Convexity	0.733	0.726
Weighted Yield (Per Cent)	7.484	7.600
Weighted Coupon Rate (Per Cent)	8.371	8.369
Weighted Clean Price (Per Cent	100.485	99.799
Weighted PV01 (Rmillion)	149.31	147.48
indexed and non-interest bearing debt		
Average Term to Maturity (Years)	14.801	14.807
Modified Duration (Years)	11.439	11.436
Convexity	1.923	1.924
Weighted Yield (Per Cent)	1.737	1.761
Weighted Coupon Ratre (Per Cent)	3.467	3.464
Weighted Clean Price (Per Cent	182.460	182.007
Weighted PV01 (Rmillion)	166.97	166.51
Total long-term debt		
Average Term to Maturity (Years)	13.220	13.215
Modified Duration (Years)	7.975	7.947
Convexity	1.019	1.015
Weighted Yield (Per Cent)	6.5335	6.6295
Weighted Coupon Rate (Per Cent)	7.191	7.187
Weighted Clean Price (Per Cent)	126.484	125.8321
Weighted PV01 (Rmillion)	317.76	315.00

Example 3: Smooth maturity profile



- Maximum amount Government is comfortable redeeming in a fiscal year.
  - Based on cash expectation and time value of money.
- FRB (Nominal) and ILB (Valued to redemption)
- Above the line would have to be switched.
- **Maximum Limits in Fixed Rate and inflation linked bonds.**

Inflation Risk Indicators

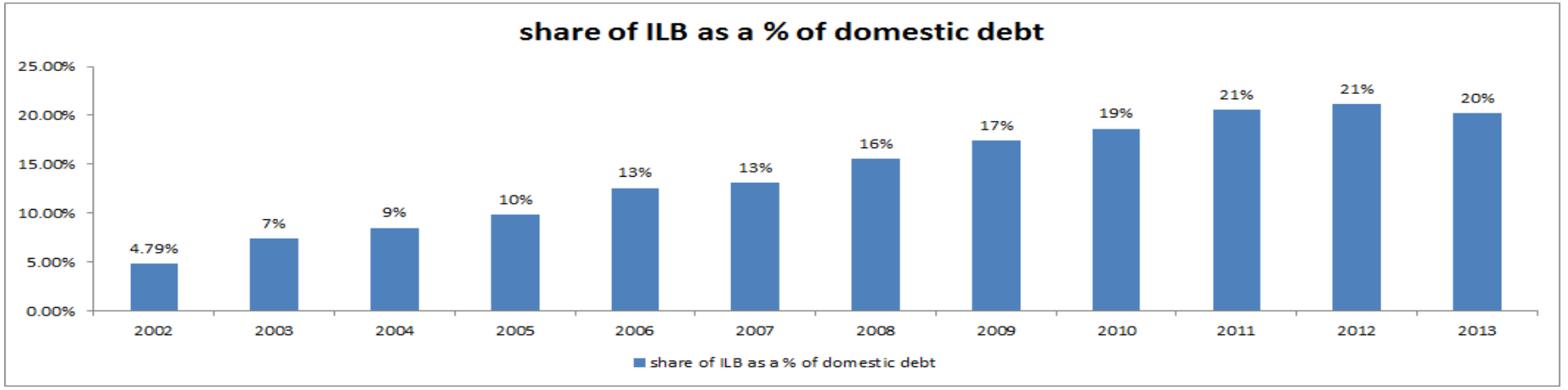
- **Portfolio Risk**
  - Share of revalued CPI debt as % of domestic debt
  - ATM of Inflation linked debt
  - Break-even inflation

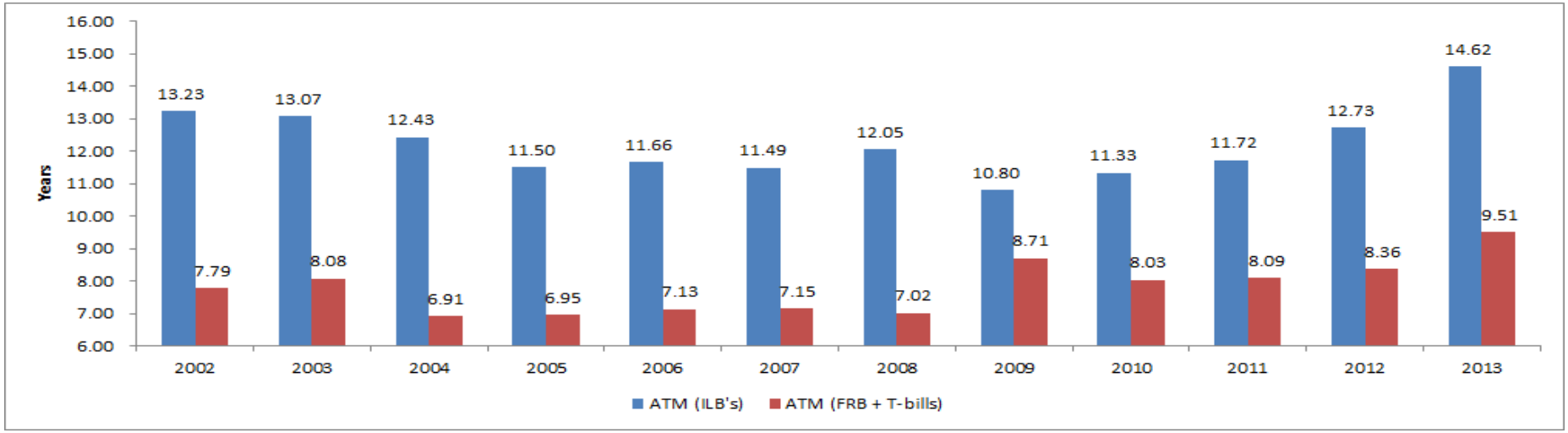
- **Debt Sustainability**
  - Share of revalued CPI debt as % of GDP
  - Deviation from the upper target band
  - Cyclicality of inflation to Revenue
  - Volatility of oil price and exchange rate

Inflation Risk Techniques and Mitigation Strategies

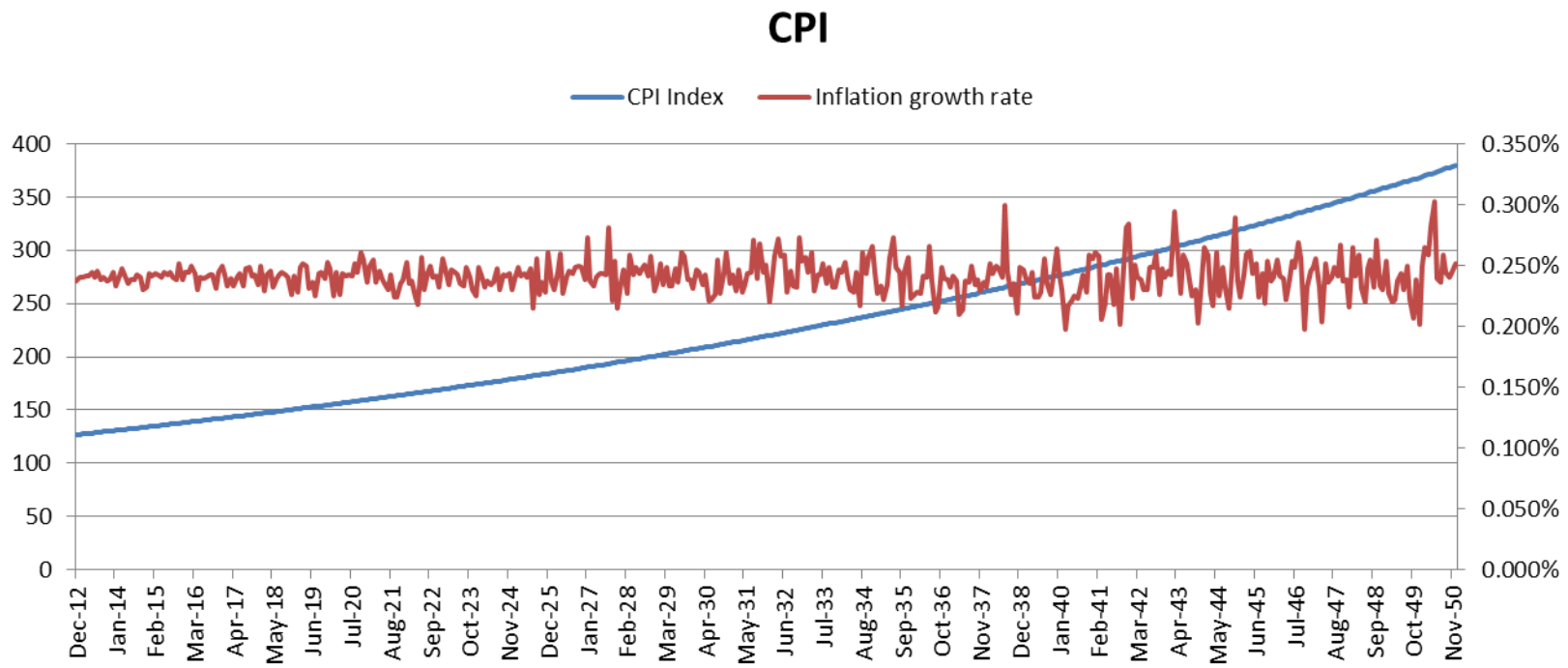
- **Techniques**
  - Geometric Brownian Motion (GBM model)
  - Cost at Risk on revalued Inflation-linked bonds
- **Mitigation Strategies**
  - Non-fixed rate debt (T-bills and inflation linked debt) limited to 30 per cent of the domestic debt portfolio.

Example 1: Inflation Risk Indicators





Example 2: Inflation Risk Techniques



Interest Rate Risk Indicators

- **Portfolio Risk**
  - Level, slope and curvature (sources of variation – yield curve risks)
  - Interest rate composition (fixed versus non-fixed)

- **Debt Sustainability**
  - Debt service cost as % of revenue and GDP
  - Impact of interest rate debt on tax revenue

Interest Rate Risk Techniques and Mitigation Strategies

- **Techniques**
  - Principal Component Analysis
  - Sensitivity Measures

    Modified duration, PV01 and Convexity
  - Conditional expectation of a given maturity(e.g. 10Y) based on the short term rate at a given time horizon (Stochastic Interest Rate Model).
  - Cost at Risk (C@R) *(on Inflation Linked debt and T-bills so far)*
  - Cash-flow at risk (CF@R) – *(work in progress - risks to weekly auctions)*

- **Mitigation Strategies**
  - Non-fixed rate debt (T-bills and inflation linked debt) limited to 30 per cent of the domestic debt portfolio.

Example 1: Interest Rate Risk Techniques

Analysis of Yield Curve Risk – March 2013

Principal Component Analysis			
Variables	Eigenvalues	Variation(per factor)	Cumulative Contributions (%)
Level	11.641	72.750	72.750
Slope	1.790	11.188	83.938
Curvature	1.067	6.668	90.606

Analysis of Yield Curve Risk – June 2013

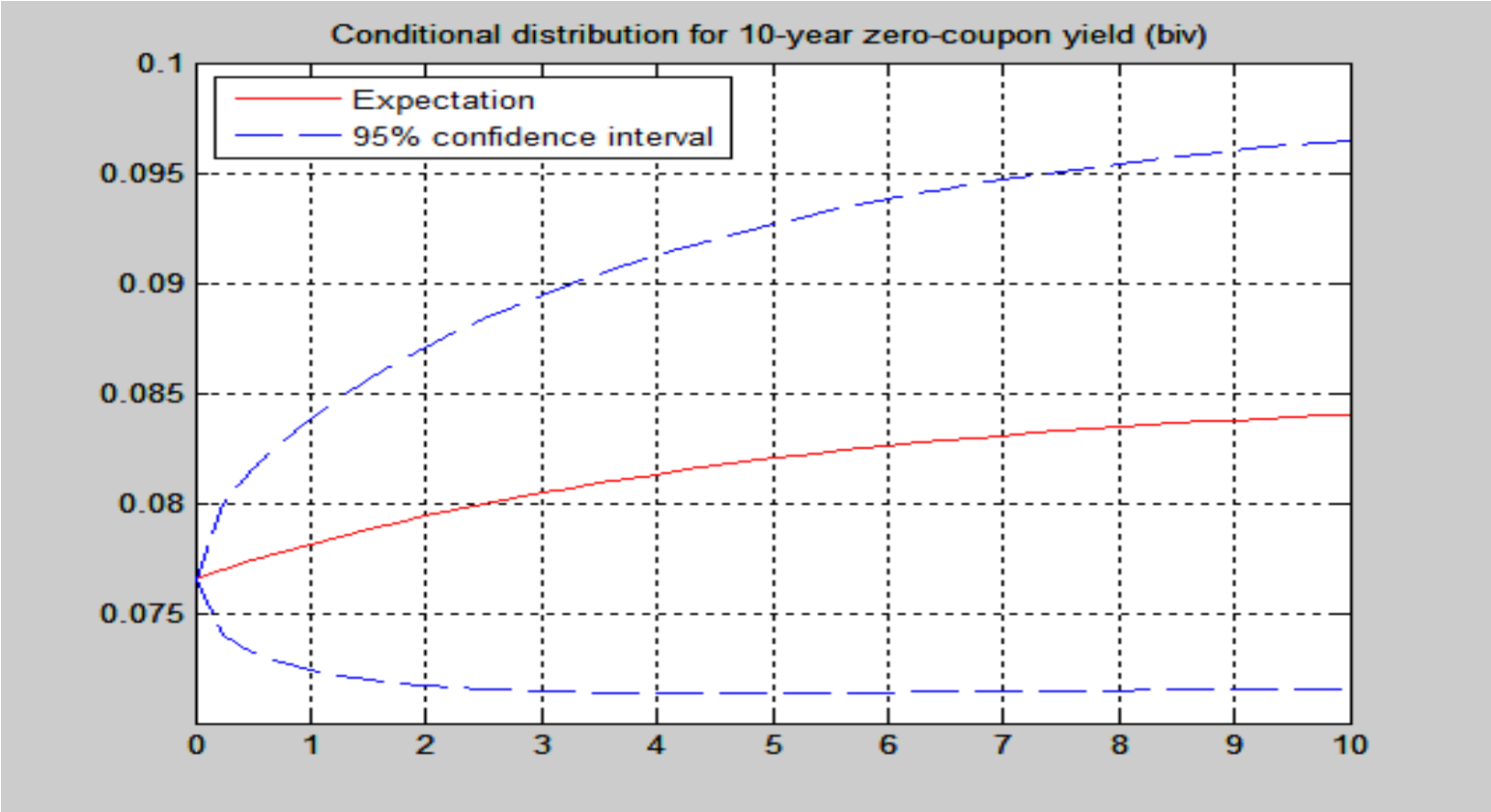
Principal Component Analysis			
Variables	Eigenvalues	Variation(per factor)	Contributions (%)
Level	12.753	79.703	79.703
Slope	2.064	12.890	92.600

- The purpose of PCA is to uncorrelate risk factor movements, therefore reducing dimensions in a huge data set.
- It is used to identify the key drivers of term structure movements, and will suggest factors/ parameters that explain most of the variability in both yields and changes in yields.
- The weights in the linear combination are determined by eigenvectors and eigenvalues are variances of the principal components.
- The principal components are ordered according to the size of eigenvalue, so that the first principal component (the one with largest variance) explain most of the variation.
- It explains the variance-covariance structure of the original variables through an orthogonal rotation such that the first principal component gives the direction of maximum variation.
- The second gives the next largest direction of maximum variability orthogonal to the first principal component and the third principal component.

Example 2: Stochastic Interest Rate Model

- Vasicek model describes interest rate movements as driven by only one source of market risk.
- In linking bond yields and prices of long term bonds (mainly zero coupon bonds) to the short rate model, one key assumptions of the model is that for any maturity, the bond yield (or spot rate) is a linear function of the current short term interest rate.
- Complete dependence on the current short term interest rates implies that in a less realistic and simple financial market, the current level of short term rates are enough to tell a complete shape of the yield curve, given some model parameters.

Example 2: Continued



Market Risk Rating Methodology

Risk Elements	Score/Rating	Description	Risk Class
Very Strong	10	Excellent	Very Low Risk
Strong Category			
strong-improving (+)	9	Strong	Moderate Risk - Low Risk
strong-static	8	Good	Moderate Risk - Moderate Risk
strong-declining (-)	7	Fair	High Risk - Moderate Risk
Stable Category			
stable-improving (+)	6	Acceptable	High Risk - Moderate Risk
stable-static	5	Marginal	High Risk - High Risk
stable-declining (-)	4	Special attention	Very High Risk - High Risk
Weak Category			
weak-improving (+)	3	Sub-standard	Very High Risk
weak-static	2	Doubtful	Very High Risk
weak-declining (-)	1	Non-viable or known losses	Very High Risk
Very Weak	0	Default	

	A **S**trategic **I**mportance	B **R**isk **P**riority	C **E**ase of **M**easurement	D **R**isk **W**eight
Range	1 - 5	1 - 5	1 - 5	10 - 125
Maximum	5	5	5	125
Formula	**A X B X C = D**			

Market Risk Rating Exercise (28 March 2013)

1. MARKET RISK	% of Currency Risk	Total FX Risk	Weight	% weighting	Strategic Importance	Risk Priority	Ease of Measurement	Risk Rating Mar 2012	Weighted Risk Rating Mar 2012	Risk Rating Mar 2013	Weighted Risk Rating March 2013	Direction of Risk
1.1 Foreign Currency Risk		**28%**										
1.1.1 Foreign debt as % of total debt	16%		125	0.1568381	5	5	5	9	1.4115	10	1.5684	↓
1.1.2 Exchange rate volatility	16%		125	0.1568381	5	5	5	9	1.4115	8	1.2547	↑
1.1.3 Current Account Deficit as % of GDP	10%		80	0.1003764	4	4	5	4	0.4015	5	0.5019	↓
1.1.4 Short term foreign debt as % of reserves	10%		80	0.1003764	4	4	5	10	1.0038	9	0.9034	↑
1.1.5 Total foreign debt as % of GDP	16%		125	0.1568381	5	5	5	10	1.5684	10	1.5684	→
1.1.6 Total Reserves as % of GDP	6%		45	0.0564617	3	3	5	9	0.5082	8	0.4517	↑
1.1.7 Impact of exchange rate on Government Revenues	2%		12	0.0150565	3	2	2	9	0.1355	9	0.1355	→
1.1.8 Changes in market value of contingent liabilities	10%		80	0.1003764	4	4	5	7	0.7026	9	0.9034	↓
1.1.9 Currency composition of foreign assets to foreign liabilities	16%		125	0.1568381	5	5	5	5	0.7842	9	1.4115	↓
			797						**7.9272**		**8.6989**	DOWN

	% of Liquidity Risk	Total LQD/REF Risk	Weight	% weighting	Strategic Importance	Risk Priority	Ease of Measurement	Risk Rating Mar 2012	Weighted Risk Rating Mar 2012	Risk Rating Mar 2013	Weighted Risk Rating March 2013	Direction of Risk
2.1 Liquidity Risk/Refinancing Risk		**25%**										
2.1.1 Smoothness of the redemption/maturity profile	18%		125	0.1785714	5	5	5	6	1.0714	7	1.2500	↓
2.1.2 Cash flow matching of coupon payments and redemptions	18%		125	0.1785714	5	5	5	9	1.6071	8	1.4286	↑
2.1.3 Deviation from projected state debt service cost	18%		125	0.1785714	5	5	5	6	1.0714	8	1.4286	↓
2.1.4 Deviation from the funding strategy	18%		125	0.1785714	5	5	5	6	1.0714	8	1.4286	↓
2.1.5 Market turnover of fixed income instruments	18%		125	0.1785714	5	5	5	8	1.4286	7	1.2500	↑
2.1.6 Crowding out effect	11%		75	0.1071429	5	5	3	6	0.6429	8	0.8571	↓
			700						**6.8929**		**7.6429**	DOWN

Market Risk Rating Exercise (28 March 2013)

	% of Inflation Risk	Total INFL Risk	Weight	% weighting	Strategic Importance	Risk Priority	Ease of Measurement	Risk Rating Mar 2012	Weighted Risk Rating Mar 2012	Risk Rating Mar 2013	Weighted Risk Rating March 2013	Direction of Risk
3.1 Inflation Risk		**20%**										
3.1.1 Deviation from "upper" targeted band	22%		125	0.2232143	5	5	5	7	1.5625	7	1.5625	→
3.1.2 Cyclicality of inflation to GDP (*cyclicality of inflation to Revenue*)	11%		60	0.1071429	5	4	3	8	0.8571	8	0.8571	→
3.1.3 Volatility of the oil price	22%		125	0.2232143	5	5	5	2	0.4464	2	0.4464	→
3.1.4 Slope of the yield curve	22%		125	0.2232143	5	5	5	9	2.0089	9	2.0089	→
3.1.5 Changes in inflation expectations	22%		125	0.2232143	5	5	5	4	0.8929	3	0.6696	↑
			560						**5.7679**		**5.5446**	UP
	% of Interest Rate Risk	**Total INT.Risk**	**Weight**	**% weighting**	**Strategic Importance**	**Risk Priority**	**Ease of Measurement**	**Risk Rating Mar 2012**	**Weighted Risk Rating Mar 2012**	**Risk Rating Mar 2013**	**Weighted Risk Rating March 2013**	**Direction of Risk**
4.1 Interest Rate Risk		**16%**										
4.1.1 Interest rate sensitivity (Duration, ATM, Rand Per Point)	22%		100	0.2207506	5	4	5	6	1.3245	6	1.3245	→
4.1.2 Interest rate composition (fixed versus floating)	28%		125	0.2759382	5	5	5	6	1.6556	6	1.6556	→
4.1.3 Interest rate composition (Index link versus nominal)	28%		125	0.2759382	5	5	5	6	1.6556	5	1.3797	↑
4.1.5 Foreign interest rate volatility	13%		60	0.1324503	4	3	5	4	0.5298	3	0.3974	↑
4.1.6 Impact of interest rate on tax revenue	4%		16	0.0353201	4	2	2	5	0.1766	6	0.2119	↓
4.1.7 Matching interest rate structure of short term assets & liabilities (*interest rate gap*)	6%		27	0.0596026	3	3	3	7	0.4172	6	0.3576	↑
			453						**5.7594**		**5.3267**	UP

Thank You

First Benchmark – 1999/2000

1. Employ a polynomial framework for modeling risk

2. Apply to Heath-Jarrow-Morton model of interest rates and FX

3. Overlay a debt management strategy and calculate its costs and risk

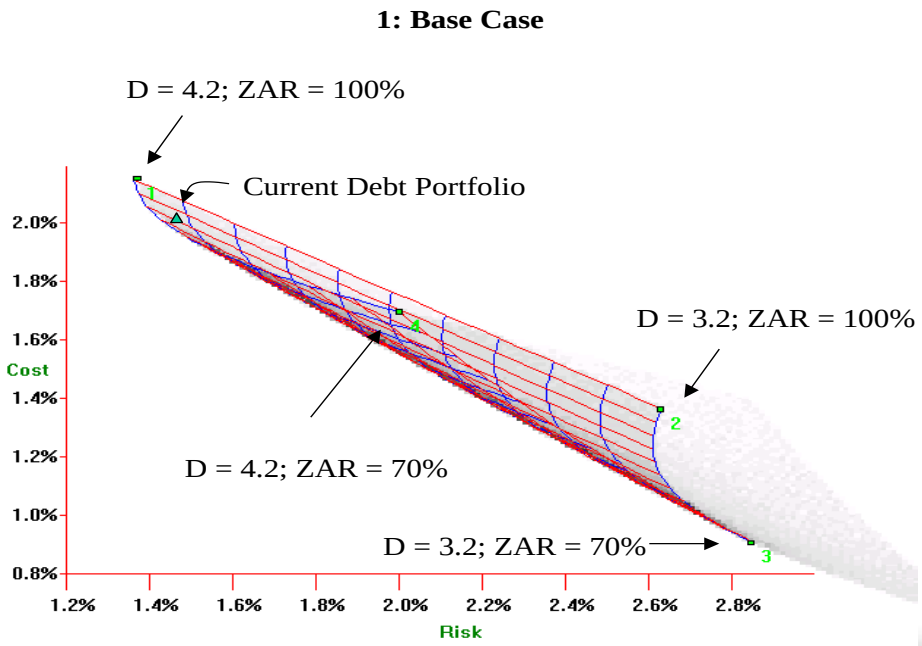
4. Repeat many strategies and deduce cost and risk as a function of strategy and assumptions

5. Determine robust efficient benchmarks

First Benchmark Results

- Domestic interest rate exposure (duration) = primary source of risk
- Foreign debt (or currency exposure) provides cost savings and diversification = determinant of efficiency

Proposal	Duration	FGN
A	4.00	7.4%
B	3.85	10.0%
C	3.85	15.0%
Current	4.16	7.4%



Second Benchmark 2005/06

"From a Duration Target to Optimal Debt Portfolio"

- **Duration measure depends on interest rate changes – not controllable.**
- **Duration measure may contradict with the strategy to lengthen maturity profile of the debt portfolio.**
- **Duration remains a good measure of cost reduction (in the long term) but not risk reduction.**
- **Optimal debt portfolio aims to find the most efficient allocation (between fixed & non-fixed) that minimises the debt cost subject to prudent risk level.**

Valuation of the Debt Portfolio

- Create a single platform for entire debt portfolio
- Develop a valuation calculator
- Analyse the debt portfolio
  - Fixed versus non-fixed
  - Domestic versus foreign
  - Maturity profile
  - Debt as % of GDP
- Calculate debt portfolio analytics
- For marketable debt:
  - Actual yield curve used to calculate discount factors and NPV
- For non-marketable domestic debt:
  - Priced off the government yield curve
- For non-marketable foreign debt
  - An average spread of RSA paper issued in the relevant foreign currency is added to the foreign yield curve

Determining the Benchmark

- **Simulation of historic portfolios consisting of the following 5 funding instruments:**
  - **Floating (ZAR) debt (treasury bills)**
  - **Fixed 5-year ZAR debt**
  - **Fixed 10-year ZAR debt**
  - **Fixed 5-year US$ debt**
  - **Fixed 10-year US$ debt**
- **Choice of funding instruments informed by available data points**

Simulation Process

- **Assume a constant monthly issuance (to address re-financing risk)**
- **Different portfolio combinations are run about 20000 times (weights kept constant)**
- **Sorted in nominal and marked to market terms**
- **Portfolio with smallest nominal amount is the optimal**
- **Penalty function introduced to calculate the cost of deviating from the optimal**

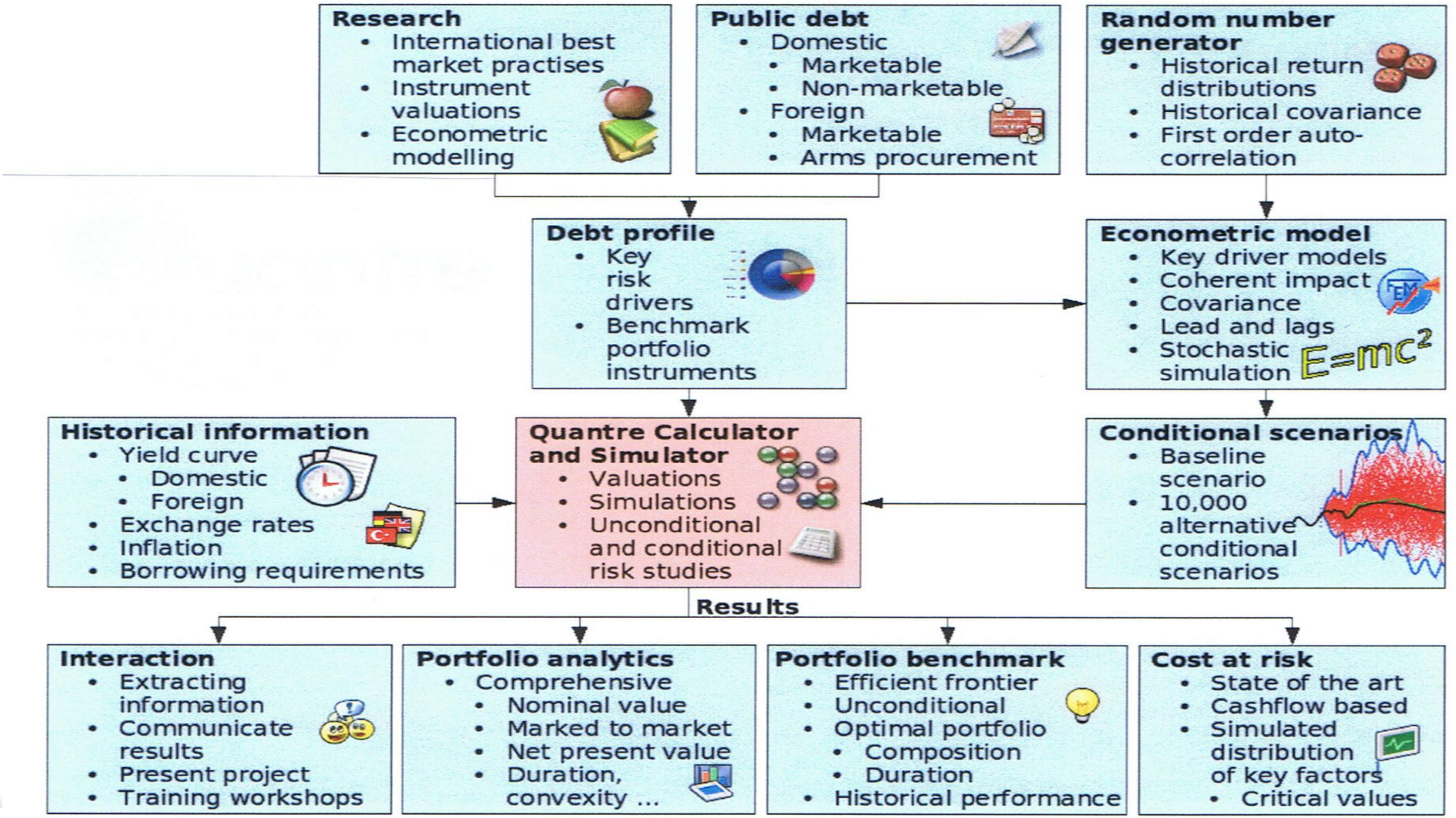
Benchmark Results

- **Best (cheapest) strategy**
  - **100% of 5 year ZAR fixed rate debt**
- **2nd best strategy**
  - **10% ZAR floating and 90% 5yr ZAR fixed rate debt**
- **Best strategy (overall portfolio)**
  - **10% ZAR floating, 80% 5yr ZAR fixed rate debt and 10% 5yr US$ fixed rate debt**

Cost-at-Risk Exercise

- **10000 econometric simulations**
- **Baseline based on a collaborative projection of risk drivers**
- **Probability distributions of risk drivers determined**
- **Calculate deviation from expected debt service cost based on**
  - **Future evolution of risk drivers and**
  - **Expected borrowing requirements**

Benchmarking Flow Diagram



Third Benchmark 2012-13

Inputs

- Cash-flows
- Primary deficit
- Financial variables
- Fiscal variables

Process

- Strategies
- Shocks
- Allocations

Outputs

Cost Indicators

- Debt Service-cost to GDP
- Debt Service-cost to Revenue
- Debt to GDP
- Expenditure to Revenue
- Revenue to GDP

Sensitivity Indicators

- Average Time to Maturity
- Share of debt maturing in 12 months
- Share of Inflation-linked debt to Domestic debt
- Fixed versus Floating debt
- Fixed versus Inflation-linked debt

Conclusion

- Debt instruments for risk benchmarks are limited to few liquid benchmark issues.
- A pure historical approach to a risk benchmark may be easy to explain, but the future evolving similar to the past is a serious issue in forward looking risk analysis.
- History should be used to derive parameters (mean and standard deviation) and then use that to simulate the future evolution to arrive at a range of outcomes.
- A deterministic approach such as the MTDS is a perfect start in preparation to move to a stochastic framework.
- As part of internal capacity building - It is never a waste of time understanding the pricing/cash flow and risk characteristics of debt instruments, e.g. inflation linked bonds in RSA case.
- A move from excel to system environment also needs a balance of human resource skills in Statistics/Mathematics, Finance, Economics/metrics. IT/Computer Science skills will be a plus!

Thank You