



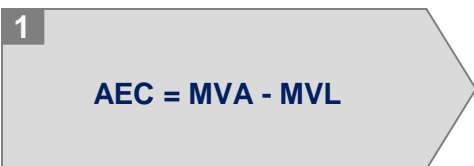
Measuring Economic Risk

Using Principal Component Analysis

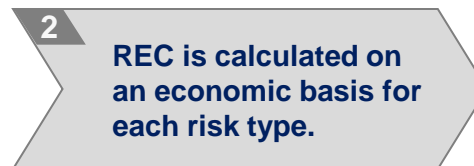
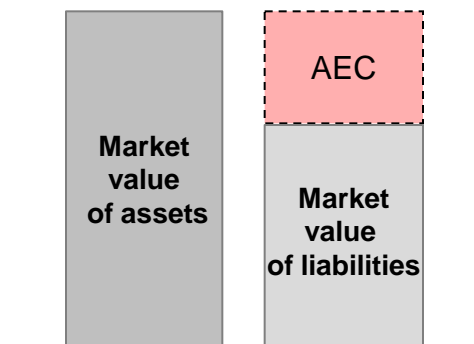
David Parsons, FSA, CERA

Albert Lo, ASA, CFA

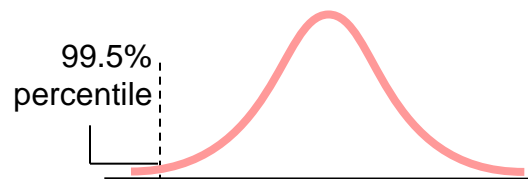
Available Economic Capital



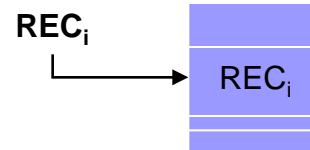
AEC = Market Value of Assets
- Market Value of Liabilities



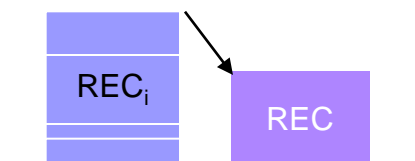
1 year Risk distribution
(e.g. equity returns)



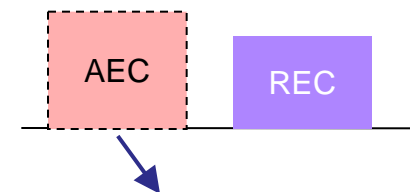
Loss distribution
(e.g. MV of VAs)



Diversification

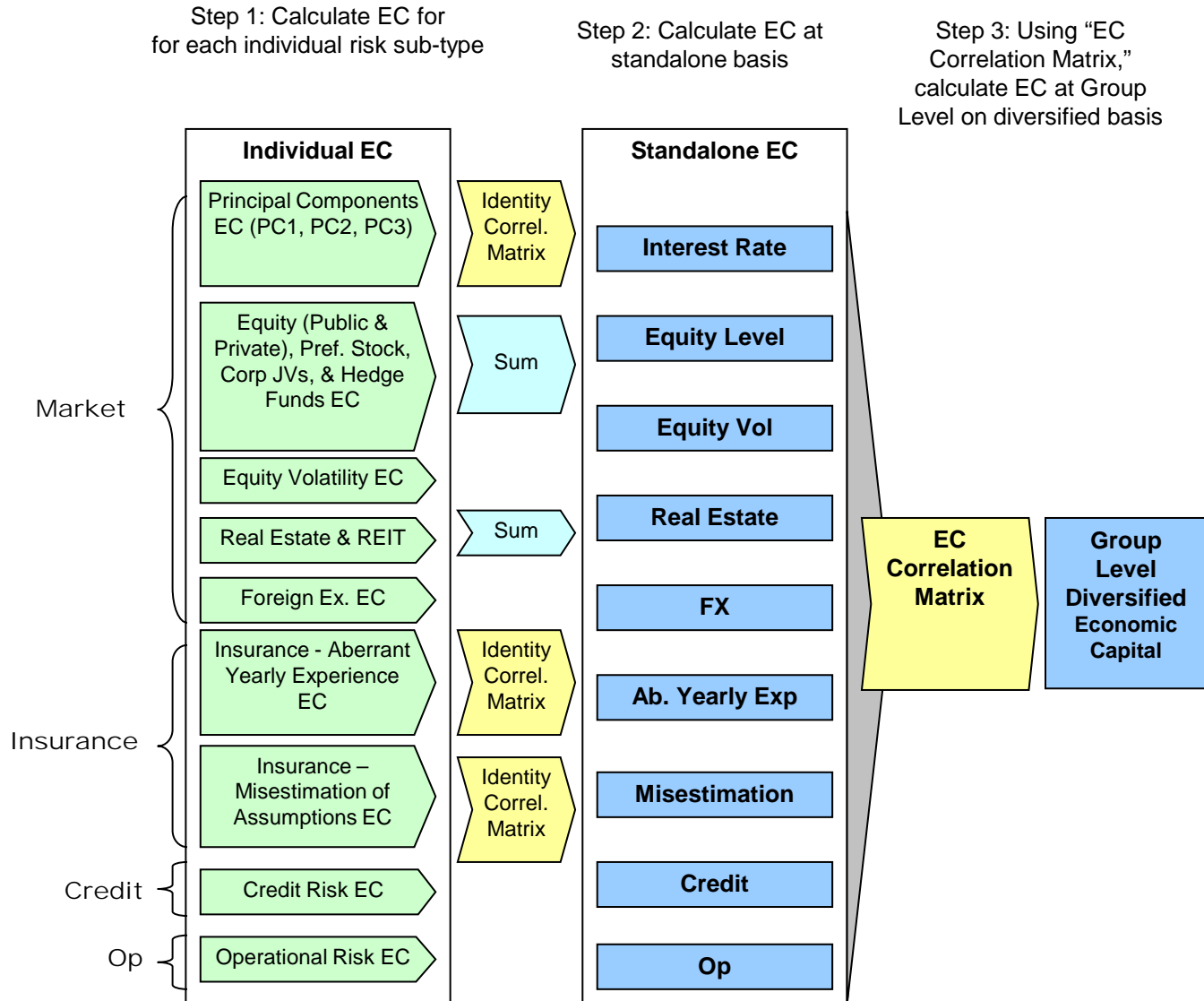


Capital adequacy



AEC represents surplus available to support REC on an economic basis.

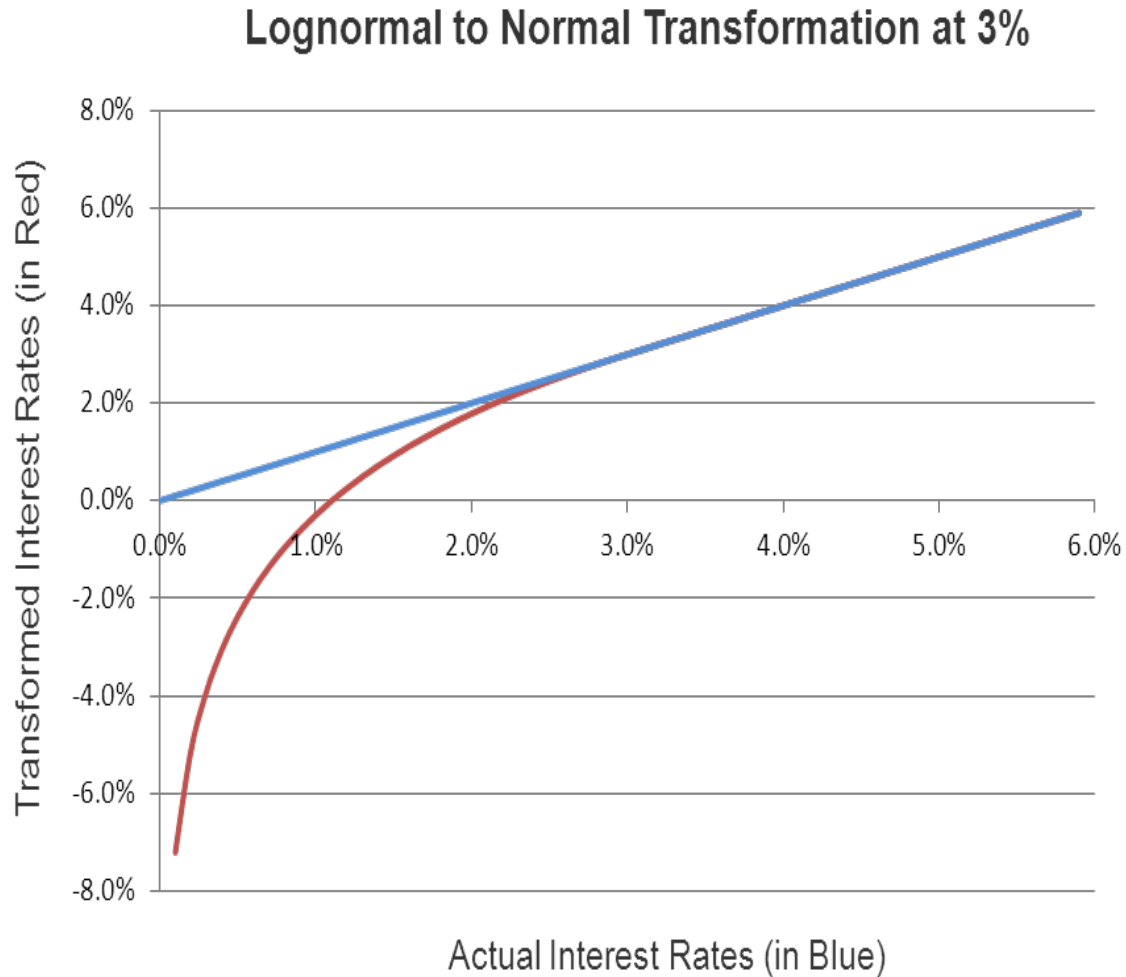
MetLife EC Calculation



Calculation of Interest Rate EC in Mexico

- **To calculate the interest rate risk for EC:**
 - Produce economic scenarios for both real (UDI) and nominal (Peso) yield curves in order to value assets and liabilities exposed to both
 - Aggregate their RECs together
- **PCA captures 99% of most yield curve movements with independent PC1 (shift), PC2 (twist), and PC3 (butterfly) at 99.5% confidence.**
- **Create a “transformed” interest rate for PCA based on a threshold**
 - Normal (above threshold): *absolute* changes are distributed normally and there is no strong relationship between volatility and rate levels
 - Lognormal (below threshold): *relative* changes are distributed normally and volatility increases linearly with interest rate levels
 - Using Bloomberg historical data: 1.5% for UDI, 6% for TIIE

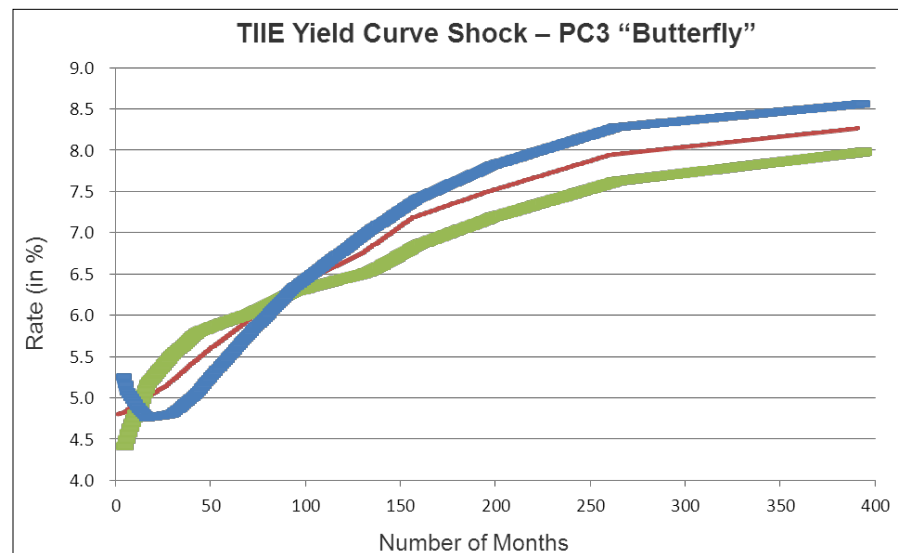
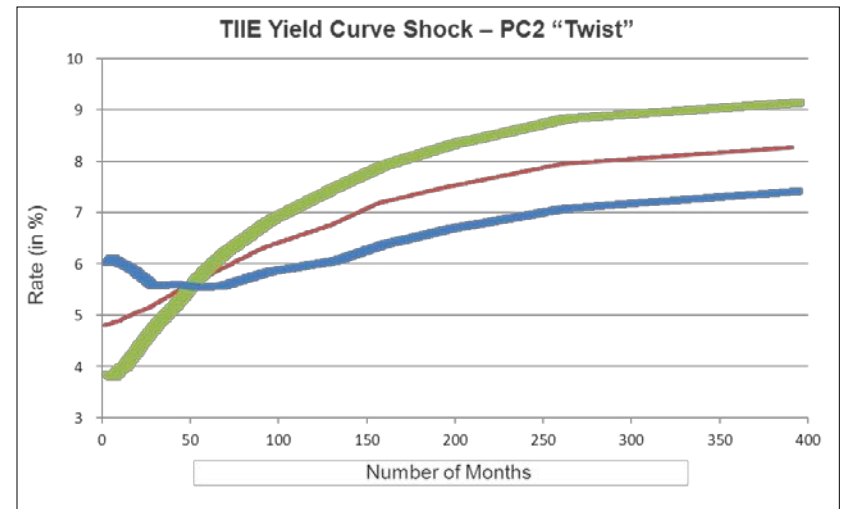
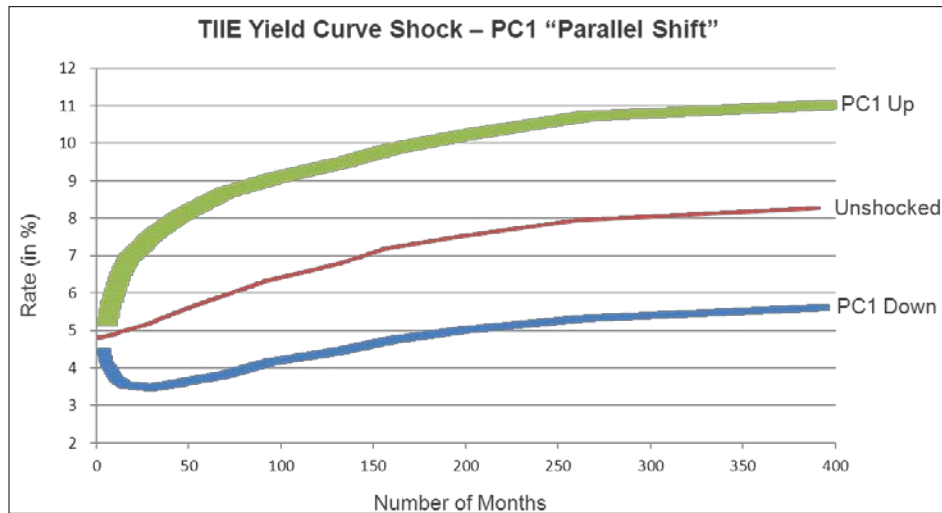
Example of Transformed Interest Rates at 3% Threshold



$$\text{Transformed} = 3\% \times \text{Log} \left(\frac{\text{Minimum}[3\%, \text{Actual}]}{3\%} \right) + \text{Maximum}[\text{Actual}, 3\%]$$

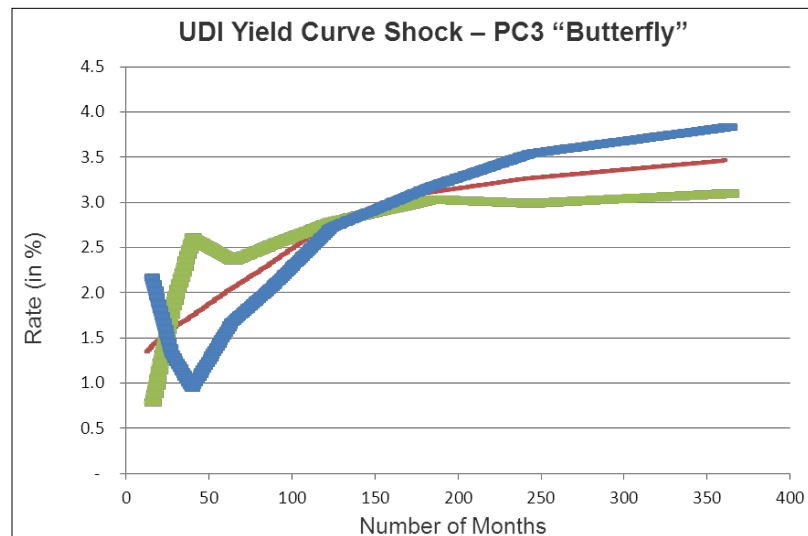
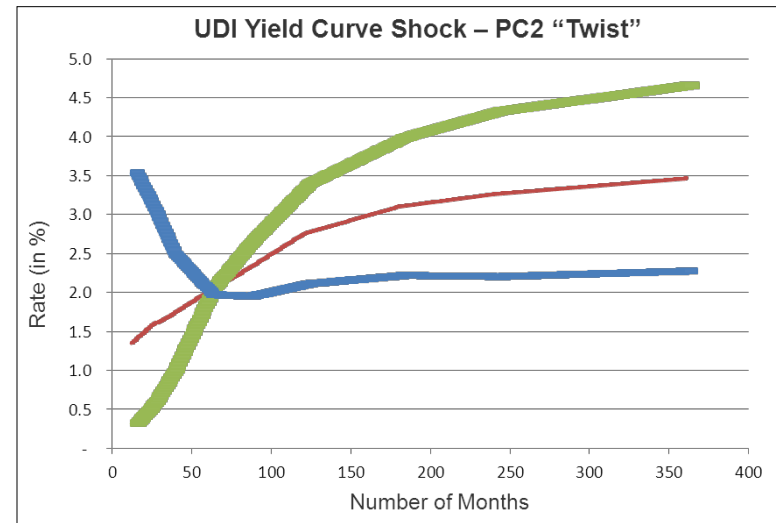
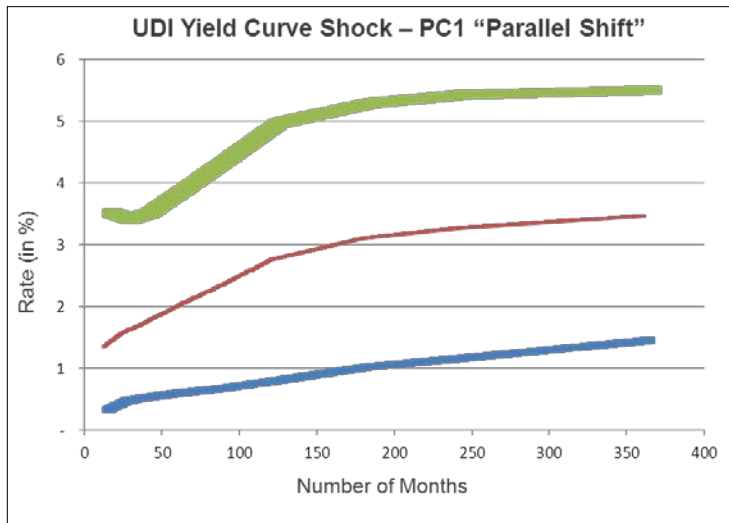
December 2011 PCA Shock Results to TIIE

TIIE Yield Curve Shocks



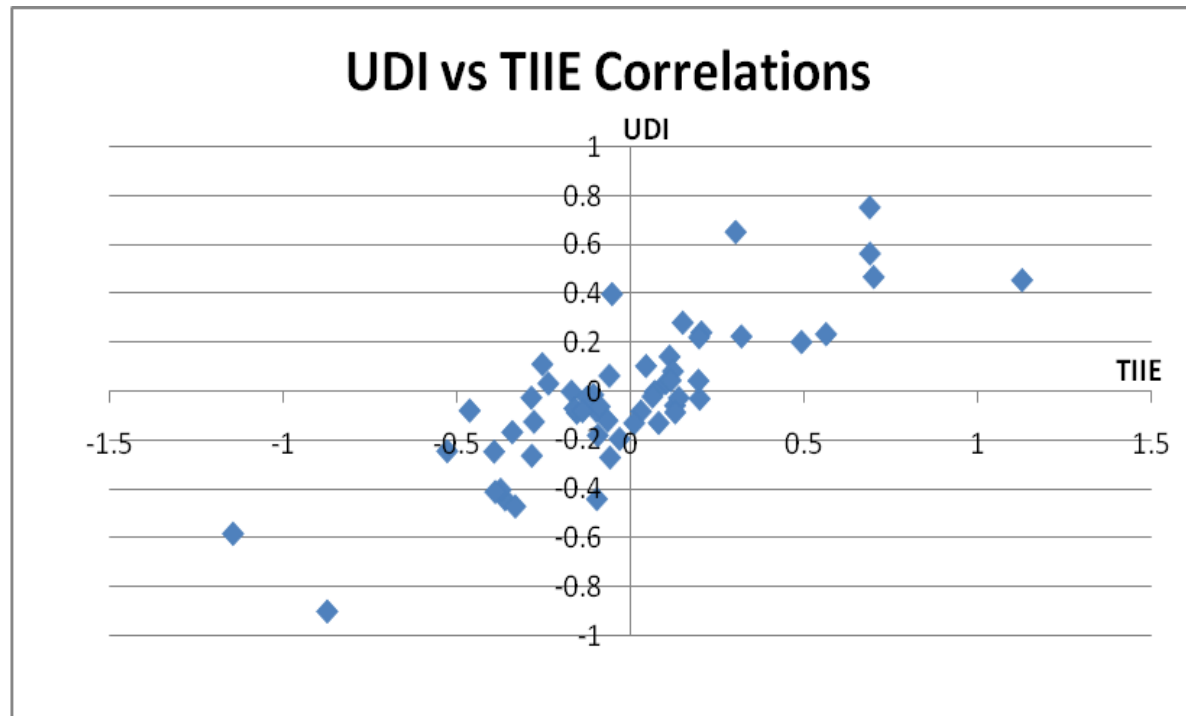
December 2011 PCA Shock Results to UDI

UDI Yield Curve Shocks



Aggregation of Interest Rate EC in Mexico

- For aggregate Mexican interest risk EC, the correlation coefficient between real and nominal rates is calculated using daily historical data from Bloomberg
- A scatter diagram of simultaneous changes in UDI (y-axis) and TIIE (x-axis) demonstrates a high degree of correlation between the two rates across all maturities, $\rho = 81.6\%$



- $EC_{AGGR}^2 = EC_{TIIE}^2 + EC_{UDI}^2 + 2 * 0.816 * EC_{TIIE} * EC_{UDI}$

Comparison of MetLife and Solvency II Approaches

- Solvency II uses a shock approach to interest rate risk, similar to PC1 shocks
- According to QIS5 instructions:
 - The magnitude of shocks are prescribed percentages, applied to the base yield curve
 - Percentages differ between downward and upward stress scenarios, and also by duration to maturity
 - Downward stress curve should not be less than a 1.0% reduction in the base yield rates
 - When QIS5 is applied to the UDI base curve, shocked rates are less severe than the 99.5% confidence level PC1+ and PC1- stresses:

UDI	12/11 Yield Curve	QIS5 Upward Stress	Equivalent PC1+ Percentile	QIS5 Downward Stress	Equivalent PC1- Percentile
1Y	1.35	2.295	87.3%	0.338	99.4%
2Y	1.57	2.669	94.0%	0.550	98.7%
3Y	1.70	2.788	94.1%	0.700	97.3%
5Y	2.01	3.116	93.4%	1.010	93.4%
7Y	2.29	3.412	92.3%	1.290	90.2%
10Y	2.75	3.905	91.1%	1.750	87.9%
15Y	3.10	4.123	88.7%	2.100	88.2%
20Y	3.26	4.108	84.5%	2.260	88.5%
30Y	3.46	4.325	86.5%	2.422	90.7%

MetLife and Solvency II Approaches (con't.)

- The QIS5 stresses are less than 99.5% PC1 stresses because:
 - UDI rates are low
 - QIS5 stresses are a percent of the base rates
- The QIS5 stresses are judged by MetLife's PC1 methodology to be more probable than 1 in 200 years
- In contrast, QIS5 stresses applied to the TIIE yield curve produce much greater stresses because TIIE nominal rates are much higher than UDI real rates:

TIIE	12/11 Yield Curve	QIS5 Upward Stress	Equivalent PC1+ Percentile	QIS5 Downward Stress	Equivalent PC1- Percentile
MXIBTIIE	4.80	8.160	99.99%	1.200	99.99%
3X1	4.81	8.177	99.99%	1.203	99.99%
6X1	4.85	8.245	99.99%	1.213	99.99%
9X1	4.88	8.296	99.99%	1.220	99.99%
13X1	4.96	8.432	99.99%	1.240	99.99%
26X1	5.14	8.738	99.98%	1.799	99.99%
39X1	5.40	8.856	99.96%	2.376	99.99%
52X1	5.64	8.968	99.92%	2.820	99.99%
65X1	5.86	8.907	99.74%	3.399	99.92%
91X1	6.31	9.276	99.74%	4.038	99.68%
130X1	6.76	9.599	99.63%	4.664	98.91%
156X1	7.18	9.837	99.49%	5.098	98.33%
195X1	7.49	9.962	99.06%	5.468	97.92%
260X1	7.94	10.004	97.29%	5.637	98.70%
390X1	8.26	10.325	97.41%	5.782	99.15%

MetLife and Solvency II Approaches (con't.)

- The QIS5-prescribed TIIE yield shocks are judged by MetLife's PC1+ and PC1- methodology to be much less probable than the prescribed UDI yield shocks:
- The QIS5 shocks do not contemplate PC2 twist or PC3 butterfly movements in the yield curves
 - Curve shocks are primarily PC1 parallel in nature
- QIS5 does not measure the impact of downward yield movements at one duration of the yield curve along with simultaneous upward movements at a different duration
- QIS5 prescribes that aggregation of interest rate risks under different currencies is a simple sum of the separately calculated risks
- If QIS5 instructions were applied to UDI and TIIE as if they were separate "currencies," then:
 - The combined risk number would reflect no diversification of the two risks (as if they were 100% correlated to each other)

Example - Simple portfolio of liabilities and assets

- Assumptions:
 - Two ten year liabilities of equal value, each 1,000 MXN
 - One liability is not inflation adjusted and will pay 1,923.47 MXN (equal to $1,000 \times 1.0676^{10}$)
 - The other liability is inflation-adjusted and will pay 1,311.65 UDI (equal to $1,000 \times 1.0275^{10}$)
 - Each liability is supported by two zero-coupon assets, 3 years and 15 years to maturity
 - Each asset is currently valued for 500 MXN
 - Two of the assets are denominated in pesos and two are denominated in inflation-adjusted UDI
 - Spot yields correspond to the December 2011 TIIE and UDI swap yield curves

Denomination	Current Value	Years Duration	Maturity Value	Annualized Yield
Assets				
Pesos	500.00	3	585.45	5.40%
Pesos	500.00	15	1,477.38	7.49%
UDI (Real)	500.00	3	525.94	1.70%
UDI (Real)	500.00	15	790.41	3.10%
Liabilities				
Pesos	1,000.00	10	1,923.47	6.76%
UDI (Real)	1,000.00	10	1,311.65	2.75%
Surplus				
Peso Assets	1,000.00			
Peso Liabilities	1,000.00			
Peso Net	-			
UDI Assets	1,000.00			
UDI Liabilities	1,000.00			
UDI Net	-			

Example (con't.)

- Changes in values of the assets, liabilities, and surplus under the stressed PC1, PC2, and PC3 scenarios:

Denomination	Years Duration	PC1-Yield	PC1-Value	PC2-Yield	PC2-Value	PC3+Yield	PC3+Value
Assets							
Pesos	3	3.56%	527.10	5.59%	497.29	5.78%	494.63
Pesos	15	5.00%	710.90	6.68%	560.20	7.18%	522.27
UDI (Real)	3	0.52%	517.86	2.49%	488.51	2.60%	487.00
UDI (Real)	15	1.01%	679.39	2.21%	569.20	3.02%	505.80
Liabilities							
Pesos	10	4.46%	1,243.76	6.05%	1,068.57	6.52%	1,023.21
UDI (Real)	10	0.79%	1,212.53	2.11%	1,064.95	2.77%	997.59
Surplus							
Peso Assets			1,237.99		1,057.50		1,016.90
Peso Liabilities			1,243.76		1,068.57		1,023.21
Peso Net			(5.76)		(11.07)		(6.31)
UDI Assets			1,197.26		1,057.71		992.79
UDI Liabilities			1,212.53		1,064.95		997.59
UDI Net			(15.27)		(7.24)		(4.80)

- PC1, PC2, and PC3 stresses for the Peso and UDI assets and liabilities are combined separately
- Combination is done by calculating the square root of the sum of the squares of the surplus deficits created under each PC scenario
 - Result: Peso risk capital requirement of 13.99 and UDI risk capital requirement of 17.57
 - Aggregate: Combining the two capital requirements produces a required risk capital number of 26.55 pesos at the 99.5% confidence level

Example (con't.)

- Impact of the QIS5-prescribed stresses on surplus values:

Denomination	Years Duration	QIS5-Yield	QIS5-Value	QIS5+Yield	QIS5+Value
Assets					
Pesos	3	2.38%	545.63	8.86%	453.87
Pesos	15	5.47%	664.81	9.96%	355.52
UDI (Real)	3	0.70%	515.04	2.79%	484.29
UDI (Real)	15	2.10%	578.71	4.12%	431.17
Liabilities					
Pesos	10	4.66%	1,219.26	9.60%	769.15
UDI (Real)	10	1.75%	1,102.74	3.91%	894.24
Surplus					
Peso Assets			1,210.44		809.40
Peso Liabilities			1,219.26		769.15
Peso Net			(8.82)		40.25
UDI Assets			1,093.76		915.46
UDI Liabilities			1,102.74		894.24
UDI Net			(8.98)		21.22

- The Peso and UDI risks are added together for total Solvency II interest EC as if they were 100% correlated, 19.80 pesos
- Compared to the 26.55 pesos from MetLife's PCA EC methodology:
 - The PCA methods produce higher UDI stresses under the PC1 parallel shift
 - Including non-parallel shifts in the Peso yield curve (especially the PC2 twist) produces higher Peso stresses than the Solvency II stresses

Summary

- MetLife's PCA methodologies for estimating interest rate risk:
 - Provide a sound basis to analyze the risk of changes in both real and nominal Mexican interest rates
 - Consider the risks of PC2 twist and PC3 butterfly changes in the shape of the yield curve, as well as PC1 parallel shifts
 - For asset-liability portfolio management purposes:
 - Matching asset durations with liability durations, without cash flow matching, will minimize the impact of PC1 parallel shifts
The portfolio may continue to be exposed to PC2 and PC3
 - These risks may be masked by a simplified risk measurement methodology (e.g.; Solvency II) that does not measure changes in the shape of the yield curve
- The PCA-based EC system produces rigorous and realistic insight into the economic risks to which the company is exposed and helps us better manage those risks

MetLife