BANK FOR INTERNATIONAL SETTLEMENTS

Fixed income performance attribution:

Problems we faced when translating theory to practice

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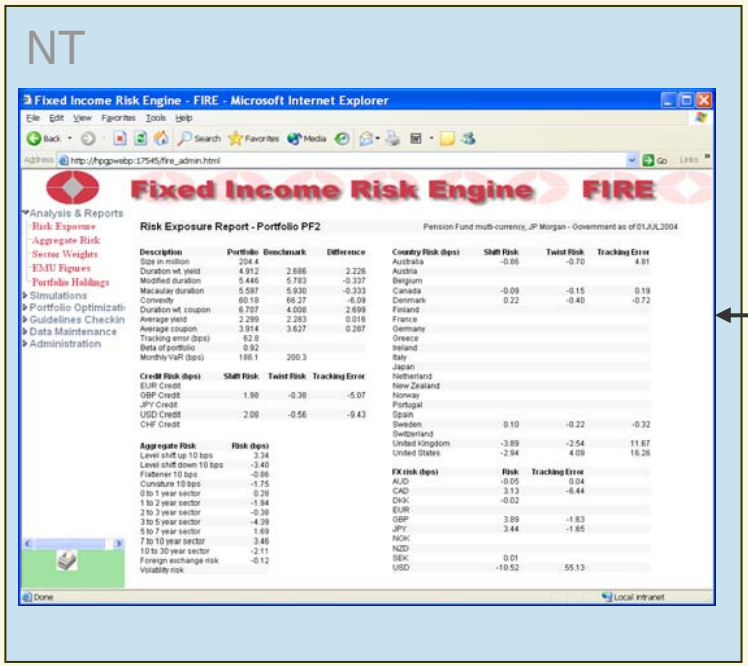
Summary of presentation

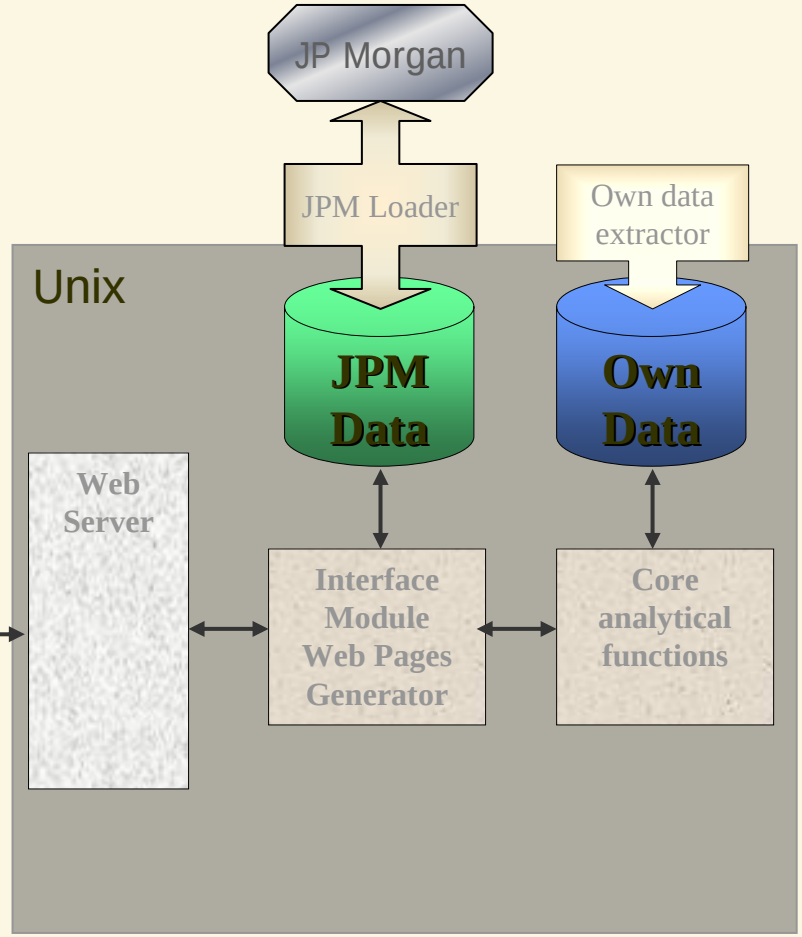
- Background
- Risk model explained
- Relevant factors to which performance is attributed
- An example performance attribution report
- Practical problems we encountered

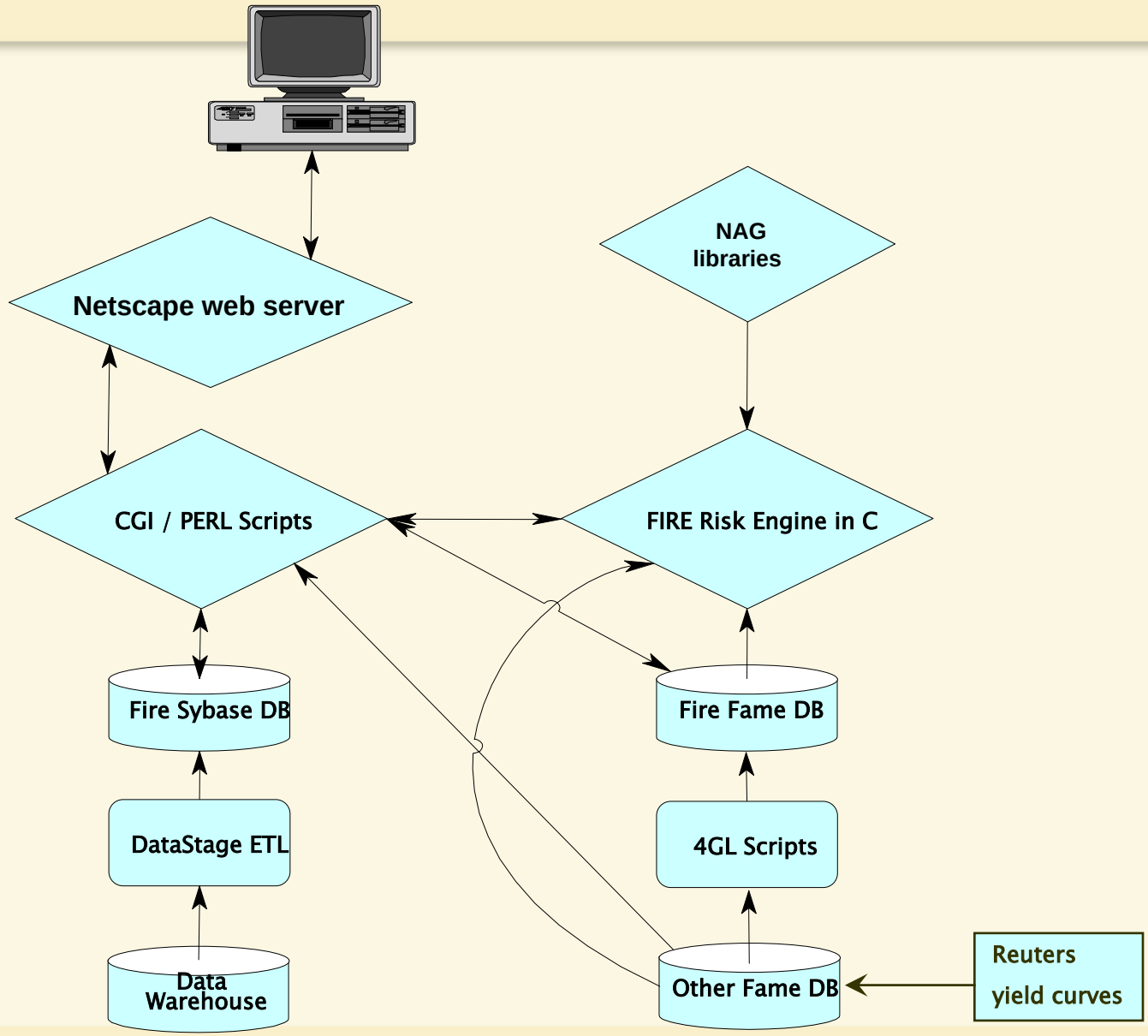
Background

- At the BIS we have developed an in-house portfolio management system to manage fixed income portfolios
- We focus primarily on high grade fixed income securities and manage single and multi-currency portfolios
- The system, Fixed Income Risk Engine (FIRE), is operational since 2001
- System initially developed to provide the following functionalities: Risk attribution, simulation capabilities, portfolio rebalancing, and performance attribution

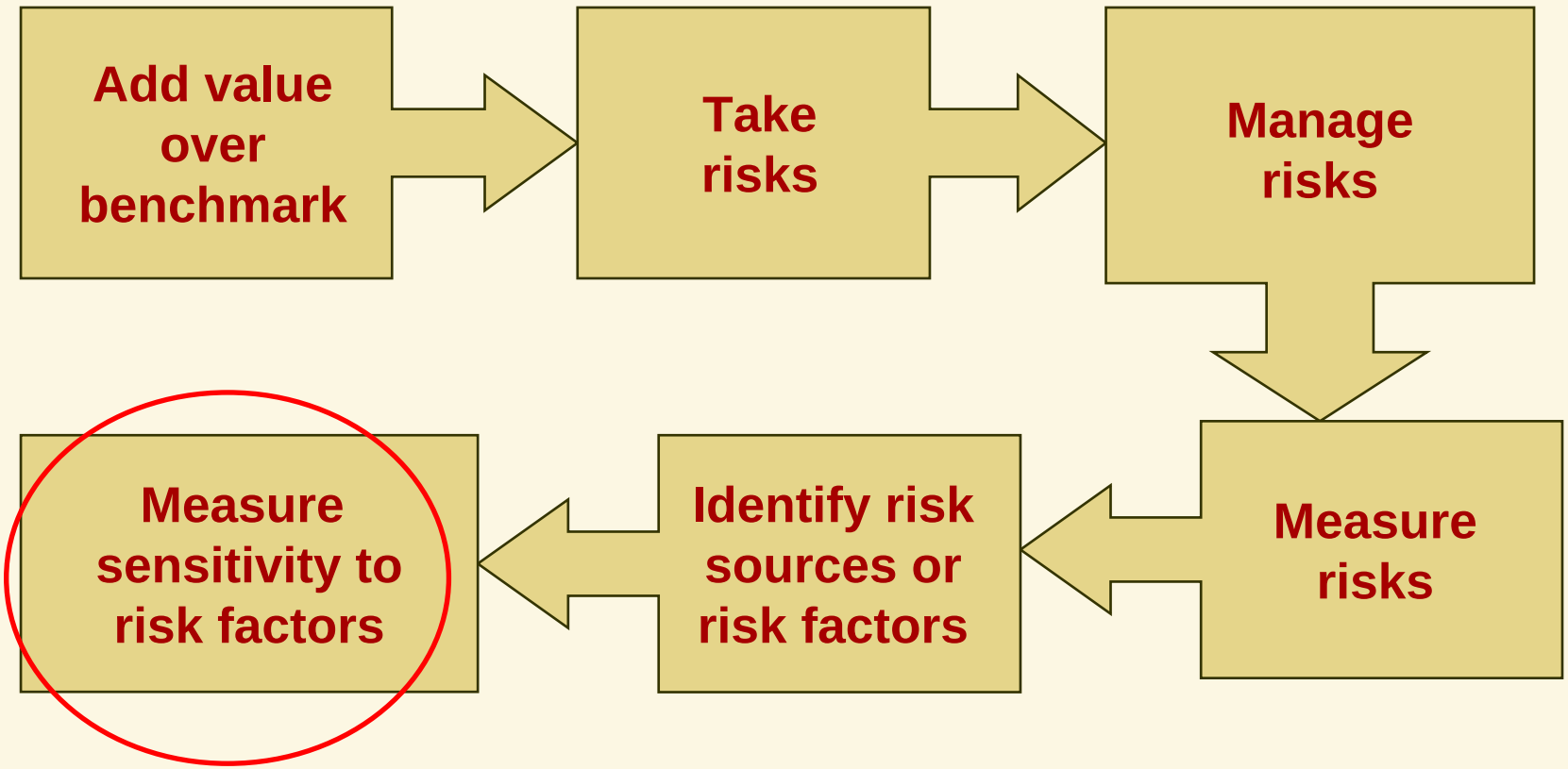
- JP Morgan (and Own data) collected on a daily basis
- Data is verified, translated and loaded into databases






Netscape web server
NAG
libraries
CGI / PERL Scripts
FIRE Risk Engine in C
Fire Sybase DB
Fire Fame DB
DataStage ETL
4GL Scripts
Data
Warehouse
Other Fame DB
Reuters
yield curves

Portfolio management: Top down approach



How it is done in practice

- Denote par yields at time *t* as $y_i(t)$ where *i* refers to the maturity
- Yield changes can be represented as

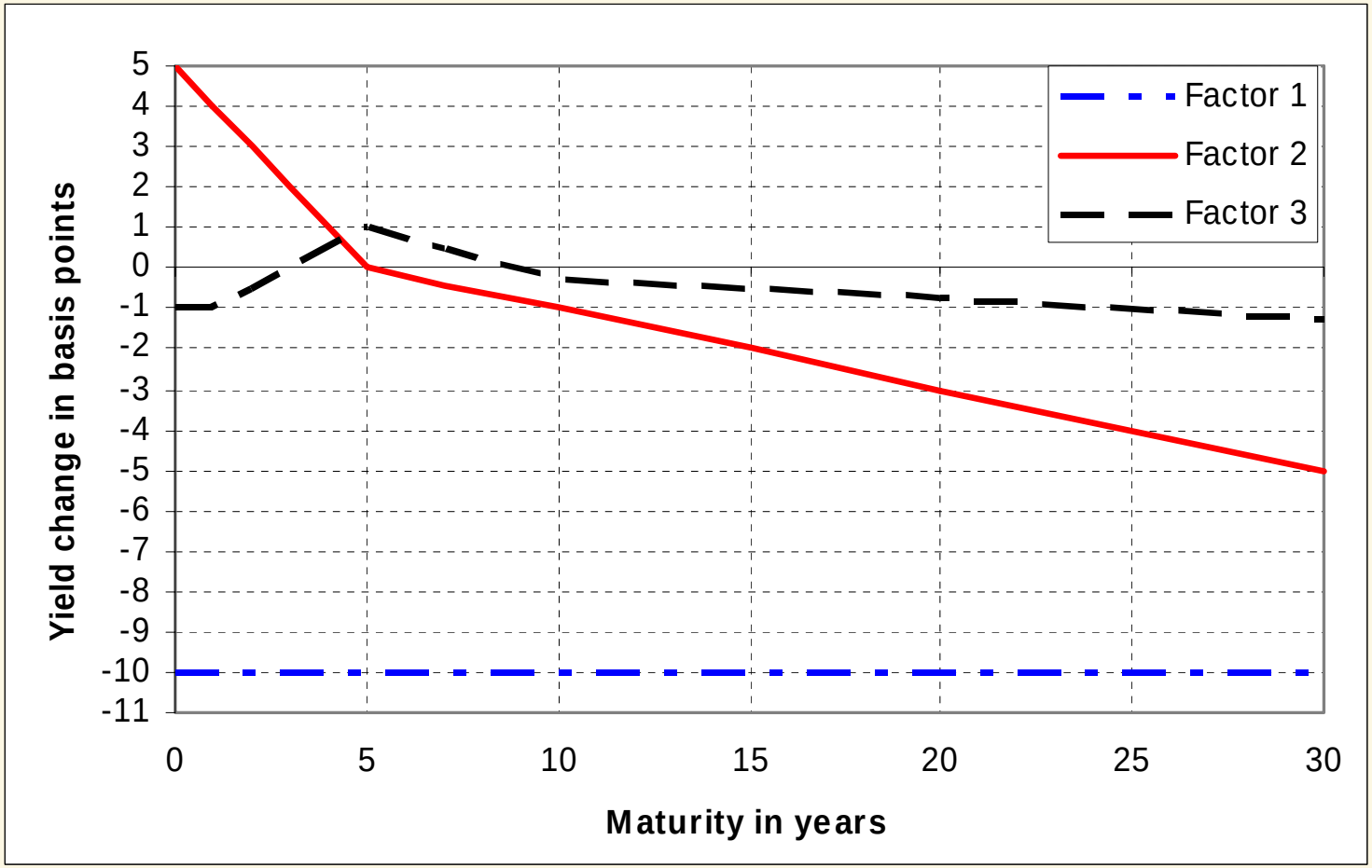
$$\Delta y_i(t) = y_i(t) - y_i(t-1), \; i = 1, 2, \cdots, n$$

- Using 2 risk factors to model yield curve shape changes, the yield changes at different maturities can be represented as

$$\Delta y_i(t) = a(t)F_1(i) + b(t)F_2(i) + e_i(t)$$

- If we know the risk factors, then we can determine coefficients a(t) and b(t) for any specific date t by minimising the sum of squared residuals $e_i(t)$

Yield curve risk factors modelled



FIRE risk model (62 risk factors)

- Foreign exchange risk is modelled as the factor sensitivity to a 1% appreciation of the foreign currency
- The coefficient associated with this risk factor is

$$c_t^k = 100 \times \frac{x_t^k - x_{t-1}^k}{x_{t-1}^k}$$

- One can estimate the market risk model using the time series of risk factor coefficients

$$\left\{\vec{\phi}(t)\right\} = \left\{\left[\, a_t^1 \quad b_t^1 \cdots a_t^m \quad b_t^m \quad c_t^1 \cdots c_t^q \,\right]\right\}$$

$$\Omega = \left[\, \Omega_{ij} \,\right] = Covariance\left[\, \{\vec{\phi}(t)\} \,\right]$$

Risk factor sensitivities

- To generate the performance attribution report we require the sensitivities to the risk factors modelled
- The basis points sensitivity of the portfolio to the shift risk factor of the *k*th yield curve on day *t* is given by

$$S_{P,S}^{k}(t) = 10000 \times \frac{M_{P,S}^{k}(t) - M_{P}(t)}{M_{P}(t)}$$

- The basis points sensitivity of the benchmark to the *k*th risk factor modelled is given by

$$S_{B,S}^{k}(t) = 10000 \times \frac{M_{B,S}^{k}(t) - M_{B}(t)}{M_{B}(t)}$$

Performance attribution report

- Performance attribution report should give break-down of excess return arising from different aggregate risk factor exposures
- Excess return between portfolio and benchmark is given by

$$R_{excess}(t) = R_P(t) - R_B(t)$$

- The daily return of the portfolio in basis points is given by

$$R_P(t) = 10000 \times \frac{Portfolio_{size}(t) - Cash_{injection}(t) - Portfolio_{size}(t-1)}{Portfolio_{size}(t)}$$

Factors for performance attribution

- For a multi-currency high grade bond portfolio, following are the factors to which performance is attributed
  - Yield curve shift (duration positions)
  - Yield curve twist (curve positions)
  - FX exposures
  - Credit spread exposures
  - Cross market exposures
  - Inter-market exposures
  - Roll and accretion (time component)
  - Residual (unexplained component)

Performance attribution report

- **Shift return component**: Explains excess return resulting from duration exposure taken relative to benchmark

$$R_{shift}(t) = a_t^B \sum_{k=1}^{m} \left(S_{P,S}^k(t) - S_{B,S}^k(t) \right)$$

- **Twist return component**: Explains excess return resulting from yield curve twist exposures relative to benchmark

$$R_{twist}(t) = b_t^B \sum_{k=1}^{m} \left(S_{P,T}^k(t) - S_{B,T}^k(t) \right)$$

Performance attribution report

- **Forex return component**: Explains excess return resulting from currency exposures in the portfolio relative to the benchmark

$$R_{forex}(t) = \sum_{k=1}^{q} c_t^k \left(S_{P,X}^k(t) - S_{B,X}^k(t) \right)$$

- **Credit spread return**: Explains excess return resulting from exposures taken to a different credit market from that of the benchmark yield curve

$$R_{credit}(t) = \sum_{k \in \Phi} (a_t^k - a_t^B) \left(S_{P,S}^k(t) - S_{B,S}^k(t) \right) + \sum_{k \in \Phi} (b_t^k - b_t^B) \left(S_{P,T}^k(t) - S_{B,T}^k(t) \right)$$

Performance attribution report

- **Cross-market return**: Explains excess return resulting from exposures taken to a different market from that of the benchmark yield curve

$$R_{cross}(t) = \sum_{k\in\Gamma}(a_t^k - a_t^B)\left(S_{P,S}^k(t) - S_{B,S}^k(t)\right) + \sum_{k\in\Gamma}(b_t^k - b_t^B)\left(S_{P,T}^k(t) - S_{B,T}^k(t)\right)$$

- **Inter-market return**: Explains excess return resulting from exposures taken in a similar market segment that is closely linked to the benchmark yield curve

$$R_{inter}(t) = \sum_{k\in\Psi}(a_t^k - a_t^B)\left(S_{P,S}^k(t) - S_{B,S}^k(t)\right) + \sum_{k\in\Psi}(b_t^k - b_t^B)\left(S_{P,T}^k(t) - S_{B,T}^k(t)\right)$$

Performance attribution report

- **Time return component**: Explains excess return resulting from accretion and roll-down which come from holding bonds considered cheap relative to benchmark curve

$$R_{time}(t) = \left(Y_P(t) - Y_B(t)\right) \times \frac{ndays}{365}$$

- **Residual return**: Explains the remaining component of excess return between portfolio and benchmark that has not been attributed
- Daily performance attribution report can be aggregated to compute the performance attribution over any time period

Performance attribution report for fixed income portfolio			
	Month to date	**Quarter to date**	**Year to date**
Comparison of total returns			
Benchmark return	1.16%	3.16%	6.97%
Portfolio return	1.25%	3.20%	7.28%
Cash return	0.40%	1.24%	4.25%
Attribution of excess returns			
Shift return	5.1 bps	-0.5 bps	6.6 bps
Twist return	0.8 bps	0.8 bps	1.2 bps
Credit spread return	0.0 bps	0.0 bps	0.0 bps
Cross-market return	0.0 bps	1.1 bps	-2.8 bps
Intermarket return	-0.6 bps	-4.7 bps	7.5 bps
Forex return	2.5 bps	4.0 bps	17.6 bps
Time return	0.1 bps	-0.2 bps	-3.5 bps
Residual return	1.1 bps	3.5 bps	4.4 bps
Total excess return	9.0 bps	4.0 bps	31.0 bps
Ex post performance figures since inception			
Sharpe ratio of benchmark	-0.48		
Information ratio of portfolio	0.23		
Annualised tracking error	39.3 bps		

Moving from theory to practice

- Portfolio valuation done using benchmark prices, which is usually captured as of close of trading
- Global multi-currency benchmark will have different market closing times
- All yield curves and FX rates captured at 5:00 pm local time
- Differences exist between portfolio and benchmark valuations and risk factor coefficients $a_k(t)$ and $b_k(t)$ which model yield curve changes
- Non-benchmark bonds in the portfolio can introduce spurious excess returns
- Trade prices are different from closing prices

Moving from theory to practice

- It is almost impossible in practice to avoid high residuals even for daily attributions (based on closing prices)
- Our experience has shown that residual return can be as high as 40%-50% of the total excess return
- We tried attributing 90% of the daily residual return to the aggregate risk factors in proportion to their month to date excess return contribution
- Experience gained over 2 years has shown us that manual intervention is frequently required to extract a meaningful performance attribution report
- After 2 years we decided to use the application for risk attribution and portfolio rebalancing only

- **Reference for risk attribution and portfolio rebalancing:**

  Srichander Ramaswamy and Robert Scott, "Managing a multi-currency bond portfolio", to appear in "*Indexing, Structured and Active Bond Portfolio Management: State-of-the-Art Investment Strategies*", edited by Frank Fabozzi, November 2005.

Thank you!