MSCI ANNUAL CONFERENCE ON **GLOBAL INVESTING AND RISK MANAGEMENT** WORKSHOP

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LOOKING FORWARD TO YOUR BACKTEST: ADVANCES IN MODEL VALIDATION

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AGENDA

- The role of the MSCI model validation team
- Insights from recent findings of the team
- Why can this be useful to me?

THE MSCI MODEL VALIDATION TEAM

- Mission:
  - Provide best practices for clients using highly configurable risk products like RiskManager: choice of data, models, statistics
- How? By developing tools, workflows, and reports that allow MSCI and clients to assess models and the quality of data on an ongoing basis
  - Single Security Analytics: how good are standard analytics delivered by MSCI?
  - Ex-ante risk forecast: which models and data should be selected for robust risk estimates?
  - Risk factors: how do we test for coverage and quality of curves in light of how this affects risk forecasts

TOPICS

Our goal is to share some of the lessons recently learnt using a few specific examples applied to BAML US High Yield and EM CEMBI indexes:

- Comparing risk factors via configurable priority choices
- Back-testing of Ex-Ante risk forecast
- Ex-Post evaluation of portfolio (and single security) returns with Standard Security Analytics

CHOICE OF RISK FACTORS

Better understanding of choices with asset modeling service

COMPONENTS OF ASSET MODELING SERVICE

- Enrichment of Exchange Traded positions
  a) Assignment of **Terms & Conditions**
  b) Identification of **Asset properties** (Sector, Rating, etc)
  c) Choice of relevant time series **(risk factors)** and pricing models
  d) Specification of model value (market price when available)
- Generation of Standard Analytics, Stress Test PnL and Risk forecast
  a) Detailed analysis of asset and portfolio diagnostics
  b) Batch report generation

TERMS AND CONDITIONS

- Exchange Traded positions fully support T&Cs enrichment for current analysis date, end-of-the-month or end-of-the-quarter historical data.
- User can provide T&C history through fully modeled positions, but this is not practical

Caution:

System historical T&Cs beyond last quarter have limited support. For example, restoring T&C of defaulted bonds requires a special configuration of the user account.

ASSET PROPERTIES AND TIME SERIES ASSIGNMENT

- T&C records created from Exchange Traded ID or user provided records are further enriched with classification tags and relevant risk time series names.
- Assignment of time series datasets and pricing models is performed according to priorities specified in a user specific tenant configuration file.
- MSCI uses default configuration accounting for potential market data license constraints, and best practices recommendations from the model validation team

Caution: the assignment of classification properties and related risk factors has similar constraints to historical T&C, i.e. re-assignment (beyond recent quarter) of sector/rating changes is not automatically supported

HOW DO WE MAKE A CHOICE? AN EXAMPLE

- Consider 4 alternative configurations for modeling assets for:
  - Bank of America Merrill Lynch US High-Yield Index (H0A0)
  - JPMorgan US Corporate Emerging Markets Index (CEMBI)

Analysis period: January 8, 2016 – March 31, 2017

Test 0	Test 1	Test 2	Base
• Bond factors: Issuer • Bond factors: Parent • Bond factors: Sector/Rating • CDS factors	• Bond factors: Parent • Bond factors: Sector/Rating • CDS factors	• Bond factors: Sector/Rating • CDS factors	• CDS factors • Bond factors: Sector/Rating

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QUESTIONS TO CONSIDER

Given selected universe of factors (different dataset types)

a) What is the coverage by dataset type today? (pricing)

b) What is the quality rank by datasets, incorporating historical coverage, granularity of data, staleness, timeliness? (risk)

For example:

If I select CDS data as first priority, and I am interested in stressing my portfolio using 2008 based scenarios, how good is the CDS dataset for this type of analysis?

FINDINGS (COVERAGE)

Notional amount coverage of JPM CEMBI Index by Curve Type (April 2017)				
Curve Type \ Data Set Priority	**Test0**	**Test1**	**Test2**	**Base**
MARKIT:CDS	0.8%	0.8%	0.8%	49.9%
MSCI:Sector/Rating	28.5%	46.9%	64.5%	14.0%
ISSUER	52.5%	32.0%	0.0%	0.0%
JPM:BLEND-YIELD	15.2%	17.0%	30.0%	34.9%
OTHER	3.0%	3.4%	4.8%	1.2%

Notional amount coverage of BofA Merrill Lynch Index Curve Type (April 2017)				
Curve Type \ Data Set Priority	**Issuer** / Parent / Sector - Rating	**Parent** / Sector - Rating	**Sector - Rating**	**CDS** / Sector - Rating
MARKIT:CDS	0.0%	0.0%	0.0%	52.1%
MSCI:Sector/Rating	51.1%	71.2%	99.7%	47.5%
ISSUER	48.7%	28.6%	0.0%	0.0%
JPM:BLEND-YIELD	0.2%	0.2%	0.3%	0.4%
OTHER	0.0%	0.0%	0.0%	0.0%

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FINDINGS (QUALITY)

- Assessment of quality depends on use case:
  - Short term risk forecast
  - Long lookback period with historical methods
  - Stress tests based on historical scenario
  - Volatility or tail risk measure

Demand on quality of data can be very different depending on the case.

✓MSCI model validation team has developed a process to answer these type of questions for general portfolios.

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BACK TESTING EX-ANTE RISK

QUESTIONS TO CONSIDER

Same example as before but, in addition to different choices of data, we now investigate:

- Risk model configuration
  - Lookback period
  - Risk methodology
  - Return horizon

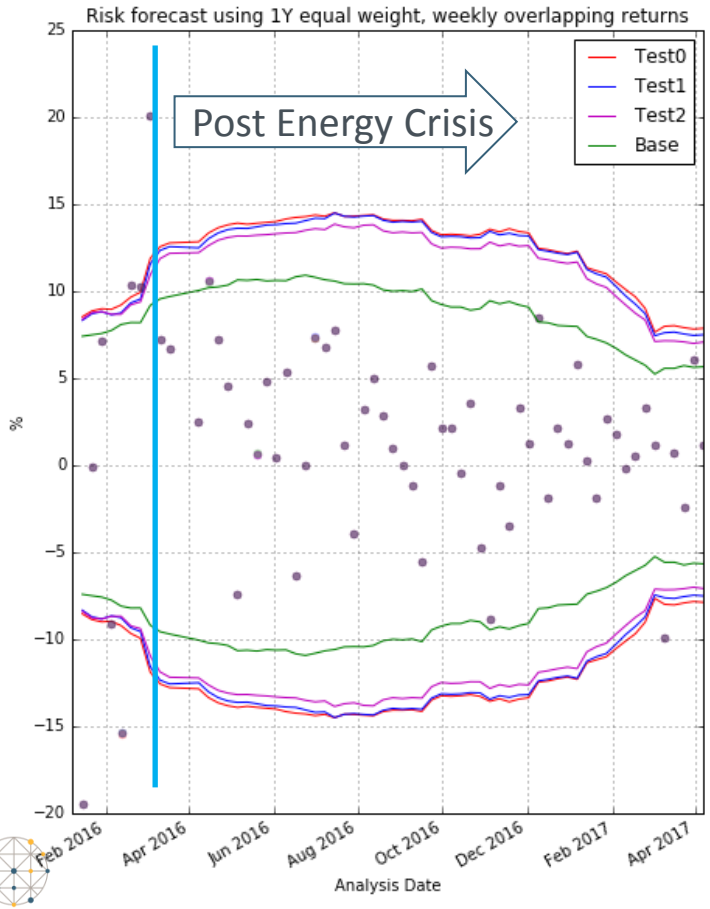
Q2: RISK MODEL SPECIFICATION

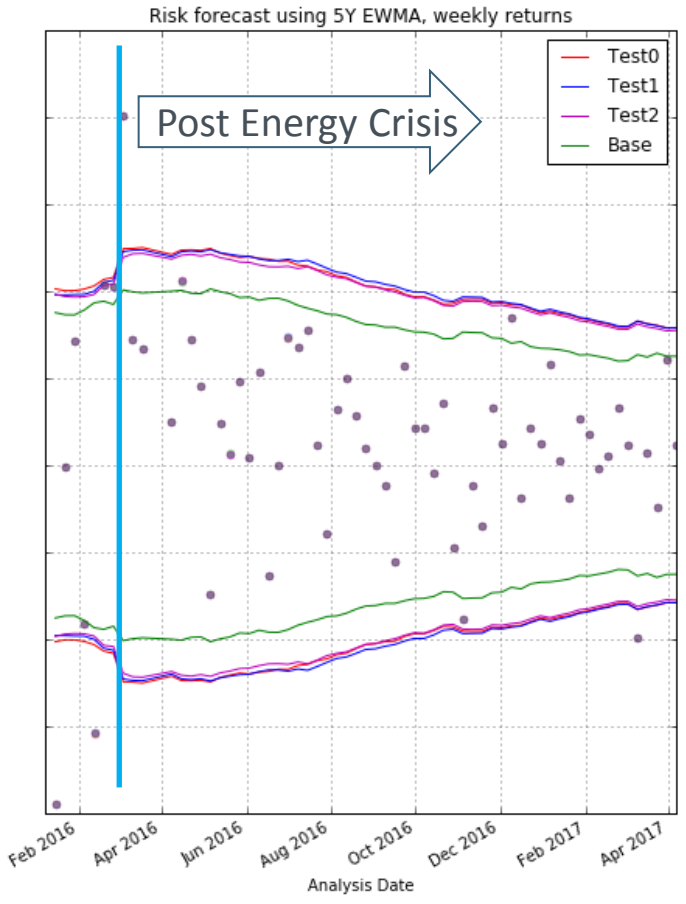
Consider two alternative configurations for the risk model

Name	1Y equal weight weekly, overlapping returns	5Y EWMA, weekly returns
History	1Y	5Y
Volatility Weighting	Equally weighted	18W Half-Life
Correlation Weighting	Equally weighted	2Y Half-Life
Overlapping Returns	4D	0D

BOFA MERRILL LYNCH US HY INDEX

2-standard deviation envelope for index returns reveals inadequate trend in risk forecast when plotted next to portfolio realized returns.





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BIAS STATISTIC

Bias statistic: how good was the volatility forecast?

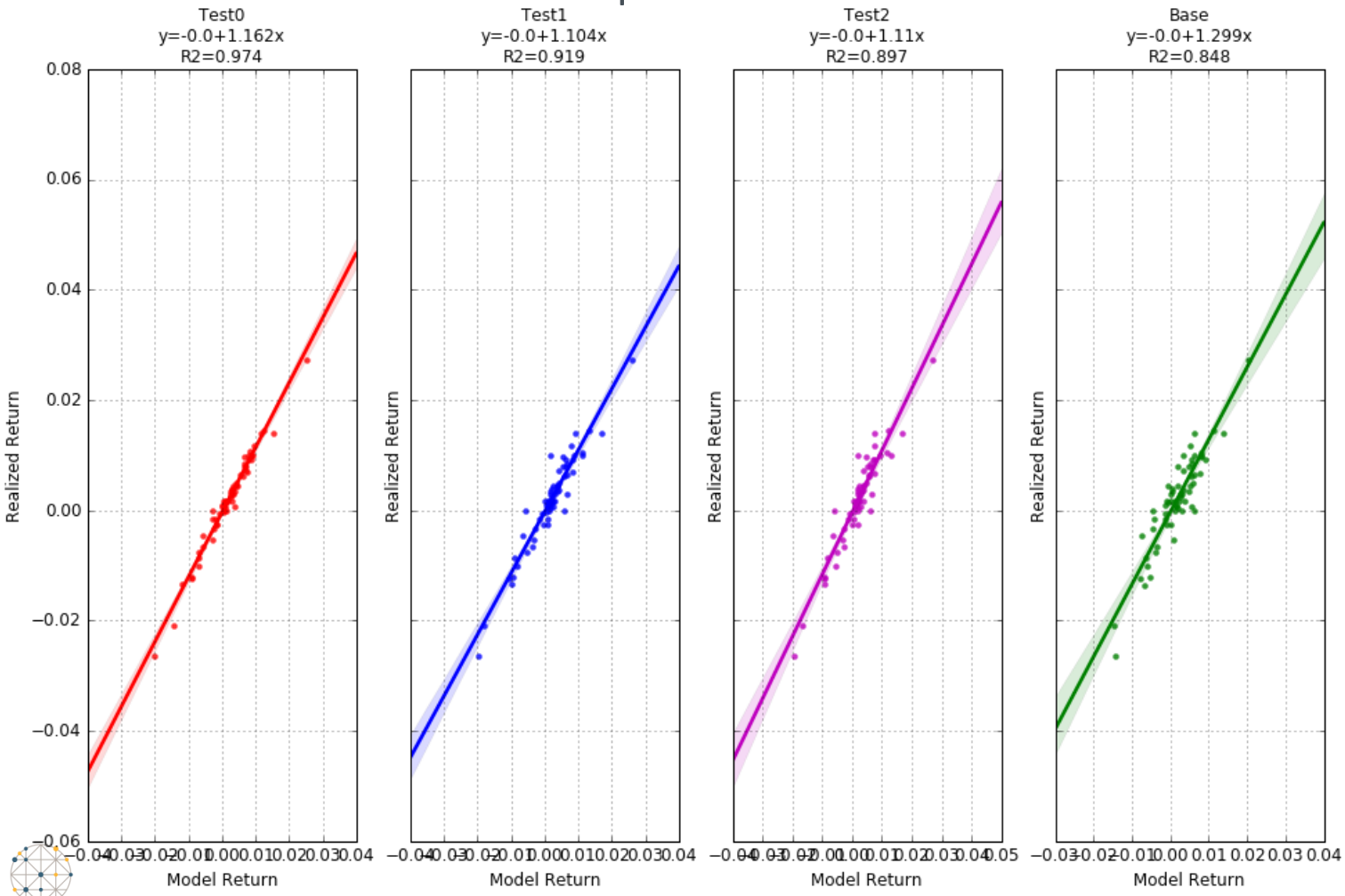
Over-forecast: Yellow (< 0.82)

Under-forecast: Red (> 1.18)

BAML H0A0	Model	Bias Statistic							
		1Y equal weight, weekly overlapping returns				5Y EWMA, weekly returns			
	Weight (%)	Test 0	Test 1	Test 2	Base	Test 0	Test 1	Test 2	Base
H0A0	100.00	1.16	1.19	1.22	1.42	1.18	1.20	1.22	1.41
Sector Drilldown									
Consumer Discretionary	19.67	1.13	1.09	1.14	1.41	1.14	1.09	1.13	1.34
Energy	13.53	1.15	1.17	1.17	1.31	1.24	1.26	1.27	1.41
Financials	11.52	1.08	1.33	1.39	1.15	1.02	1.20	1.29	1.11
Telecommunication Services	11.35	0.99	1.03	0.93	1.17	1.04	1.03	0.93	1.18
Industrials	10.77	1.24	1.27	1.36	1.48	1.13	1.10	1.21	1.36
Materials	9.47	1.00	1.07	1.19	1.34	1.04	1.12	1.20	1.34
Health Care	9.13	1.37	1.29	1.55	1.41	1.38	1.35	1.55	1.55
Information Technology	5.73	1.00	0.89	0.89	1.20	0.97	0.86	0.85	1.05
Consumer Staples	3.65	1.25	1.01	0.94	1.23	1.04	0.85	0.83	1.08
Utilities	3.29	1.11	1.16	1.16	1.29	1.15	1.18	1.21	1.37
Real Estate	1.88	0.99	0.89	0.92	1.65	0.95	0.87	0.89	1.60

MODEL VS ACTUAL RETURN R^2: US HY INDEX

Regression analysis of model vs. actual return allows for additional differentiation of risk factor Ex-Post performance



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JPM CEMBI BIAS STATISTIC

Bias statistic: how good was the volatility forecast?

Over-forecast: Yellow (< 0.82)

Under-forecast: Red (> 1.18)

JPM CEMBI		Bias Statistic							
	Model	1Y equal weight, weekly overlapping returns				5Y EWMA, weekly returns			
	Weight (%)	Test 0	Test 1	Test 2	Base	Test 0	Test 1	Test2	Base
CEMBI	100	0.93	1.01	1.15	1.08	0.97	1.01	1.11	1.01
Top 12 Countries									
KY	10.57	0.85	0.91	0.93	1.24	0.95	0.99	1.01	1.16
VG	9.17	1.11	1.12	1.26	1.10	1.09	1.10	1.11	1.04
HK	8.09	0.99	1.34	1.34	0.78	1.08	1.19	1.19	0.87
CN	7.36	1.16	1.23	1.28	0.85	1.06	1.11	1.13	0.85
LU	7.10	0.72	0.80	0.95	1.19	0.77	0.81	1.01	1.24
NL	7.09	0.72	0.70	1.28	1.03	0.91	0.89	1.37	1.05
MX	5.50	1.04	1.13	1.22	0.74	1.05	1.09	1.11	0.73
AE	4.10	1.06	1.08	1.25	1.01	0.9	0.92	1.17	0.94
IE	3.75	0.70	0.70	0.74	0.98	0.61	0.61	0.68	1.12
US	3.56	0.91	0.95	1.11	0.81	0.84	0.87	1.06	0.88
BR	3.23	1.00	1.11	1.42	1.17	1.12	1.20	1.59	1.18
TR	3.15	1.06	1.68	1.80	1.21	1.09	1.62	1.74	1.17

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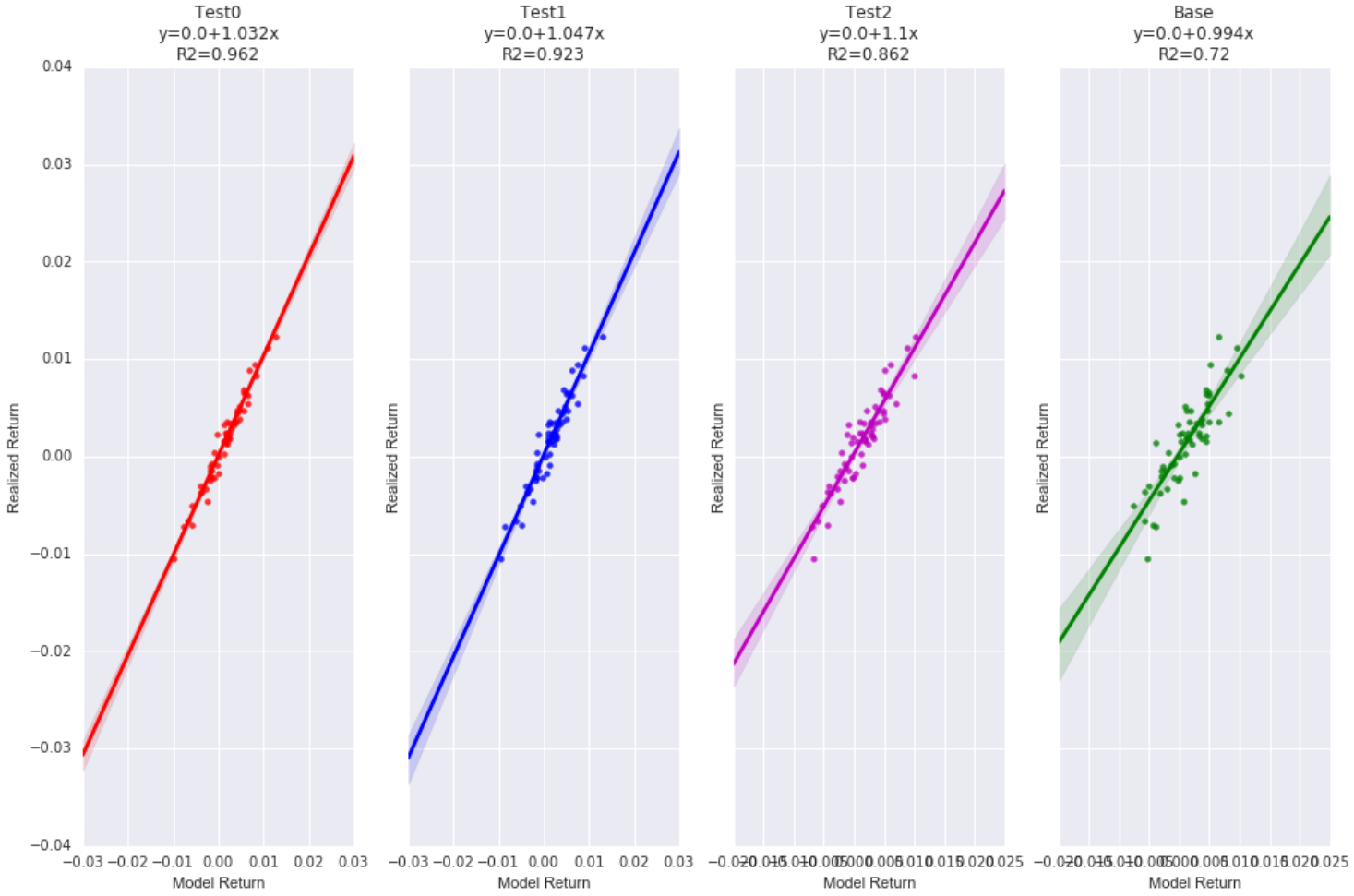
MODEL VS ACTUAL RETURN R^2: JPM CEMBI INDEX

Regression analysis of model vs. actual return allows for additional differentiation of risk factor Ex-Post performance



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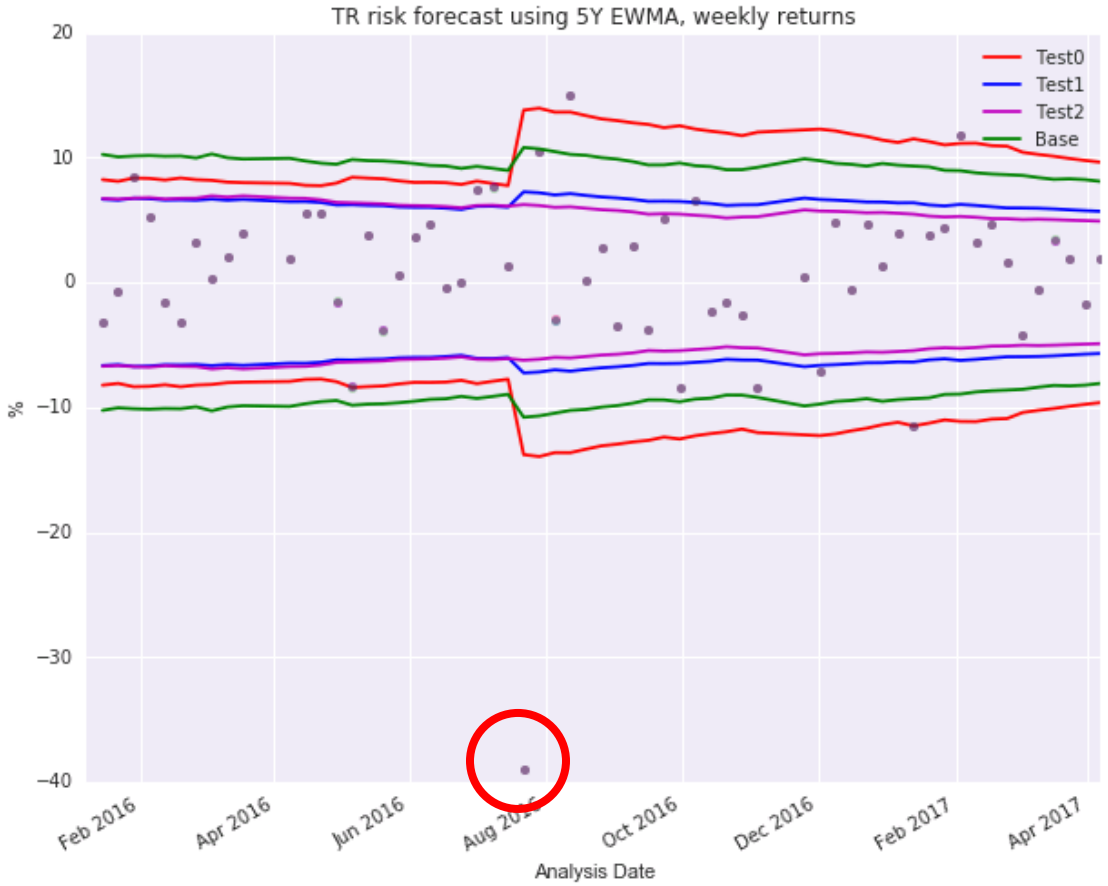
JPM CEMBI: TURKEY

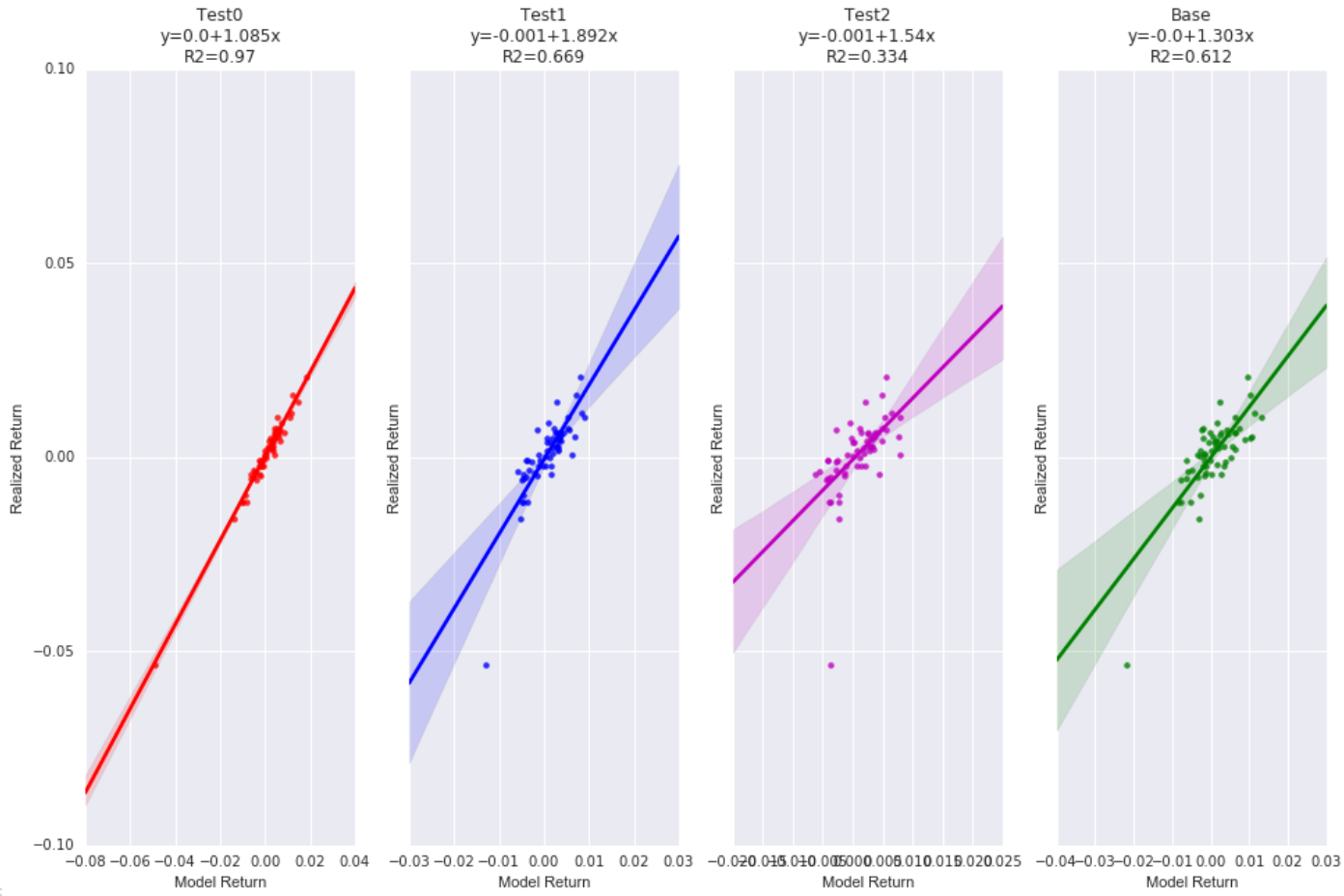
Why isn't Test2 reacting?

- USD sector-rating curves did not react to attempted coup in Turkey



JPM CEMBI: TURKEY

Comparison of model vs. actual returns



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USING SINGLE SECURITY ANALYTICS TO FURTHER ANALYZE REALIZED RETURNS

PORTFOLIO RETURN DECOMPOSITION

- RiskManager provides a set of FI Standard Security Analytics (SSA) that allows attribution of Ex-Post portfolio return along relevant factor type dimensions.
- SSA set consist of the following statistics:
  - Option-Adjusted Duration (OAD) and its Key-Rate decomposition
  - Option-Adjusted Spread Duration (OASD) and its Key-Rate decomposition
  - OAS over Government and Swap curves
  - IR Volatility and IR Volatility Duration
  - FX and Equity Elasticity
- The link between risk factor changes, position SSA, and portfolio returns can be established using statistics used with historical stress-by-date

RETURN DECOMPOSITION: EXAMPLE

Fixed-coupon bond with embedded optionality:

$$\left[\frac{1}{P}\Delta P\right] = \sum_{T} D_{G,T}\Delta R_G(T) + \sum_{T} D_{S,T}\Delta R_S(T) + \sum_{T} D_{\sigma_{IR},T}\Delta\sigma_{IR}(T) + e$$

- $\Delta R_G(T)$ changes in Govt curve levels
- $\Delta R_S(T)$ changes in Credit Spread curve
- $\Delta\sigma_{IR}(T)$ changes in vol
- D delta equivalents
- e residual bond return not explained by risk factors

This can be further extended to second order sensitivities to reduce the residual term for positions with significant convexity.

EXPOSURE REPORT

We can create portfolio level reports showing exposures to each time series (risk factor):

1. Using deltaEquivalents statistic

   Determines the sensitivity of position Present Value to a % change in each underlying risk factor “price”.

2. Using deltaStressPVUserDefined together with deltaStressRFUserDefined

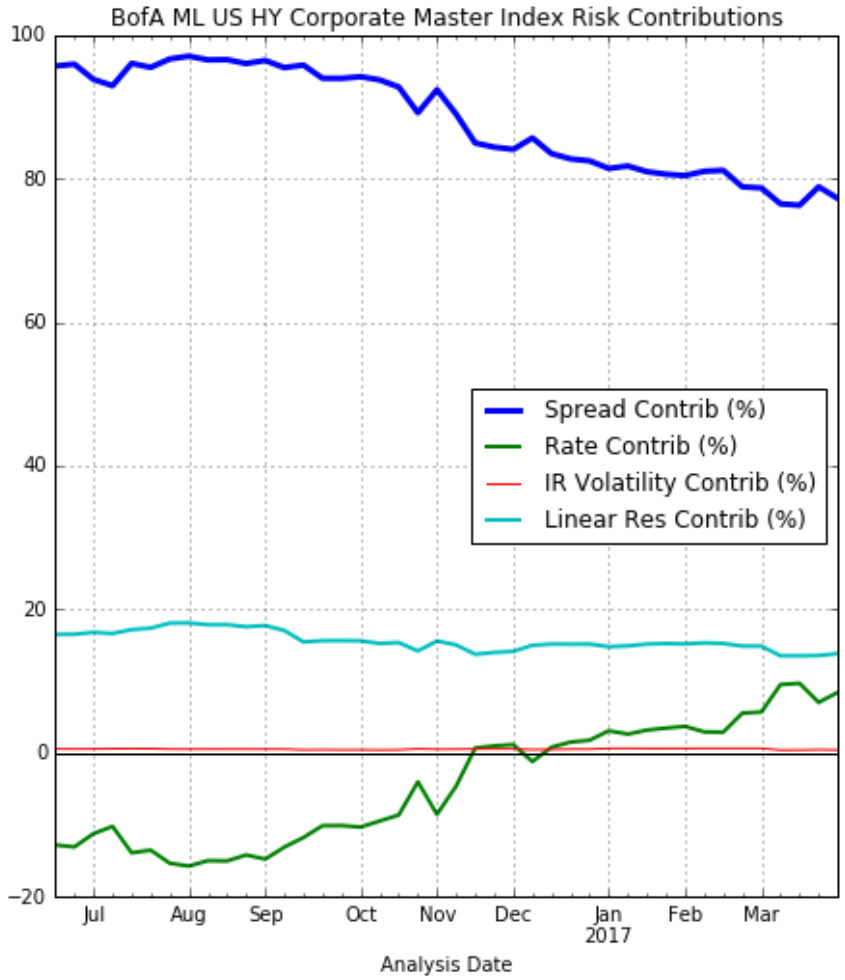
   Determines changes in times series levels for each relevant risk factor in a stress test.

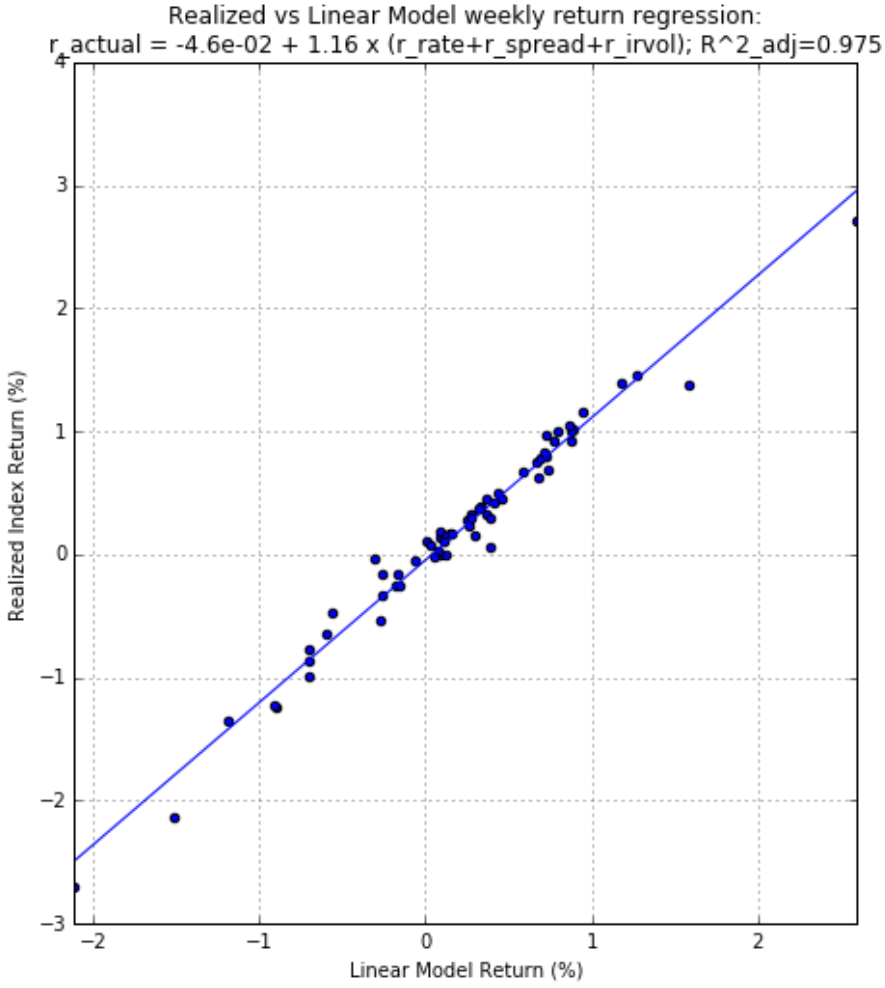
   ✓Using these stats with historical stress-by-date allows calculation of asset/portfolio historical PnL contributions for each factor type.

BACKTEST RESULTS ARE IMPACTED BY…

1. Pricing model alternatives
2. Credit risk modeling alternatives
3. Risk factors

SSA VALIDATION (BAML US HIGH YIELD)





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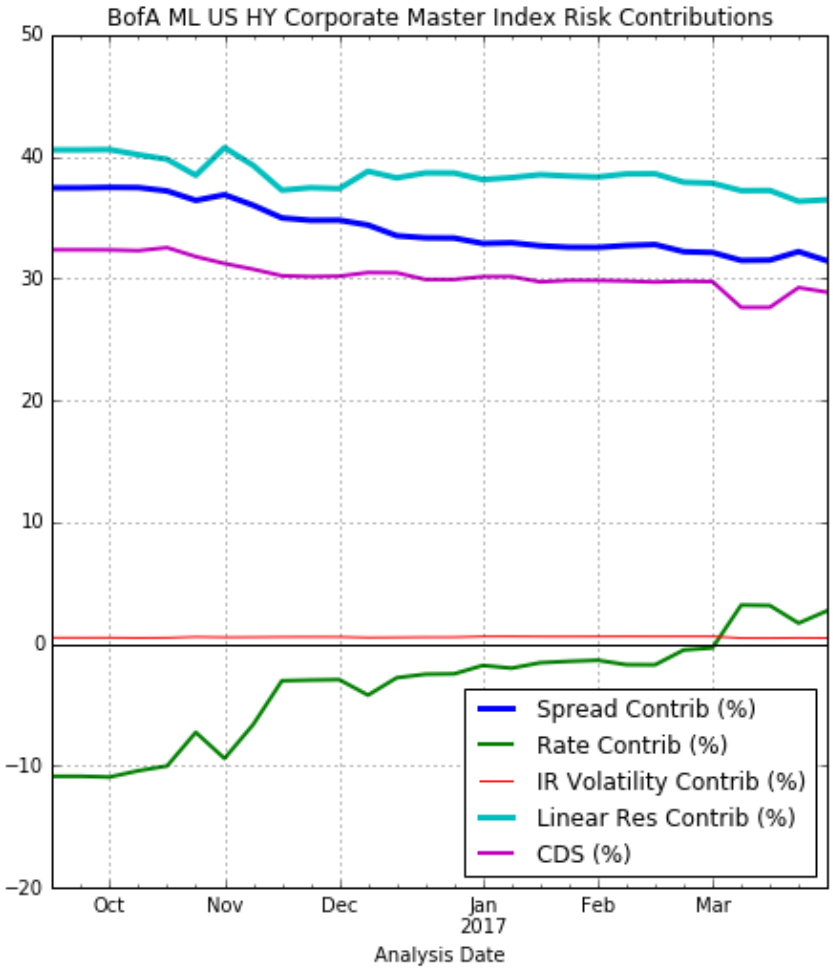
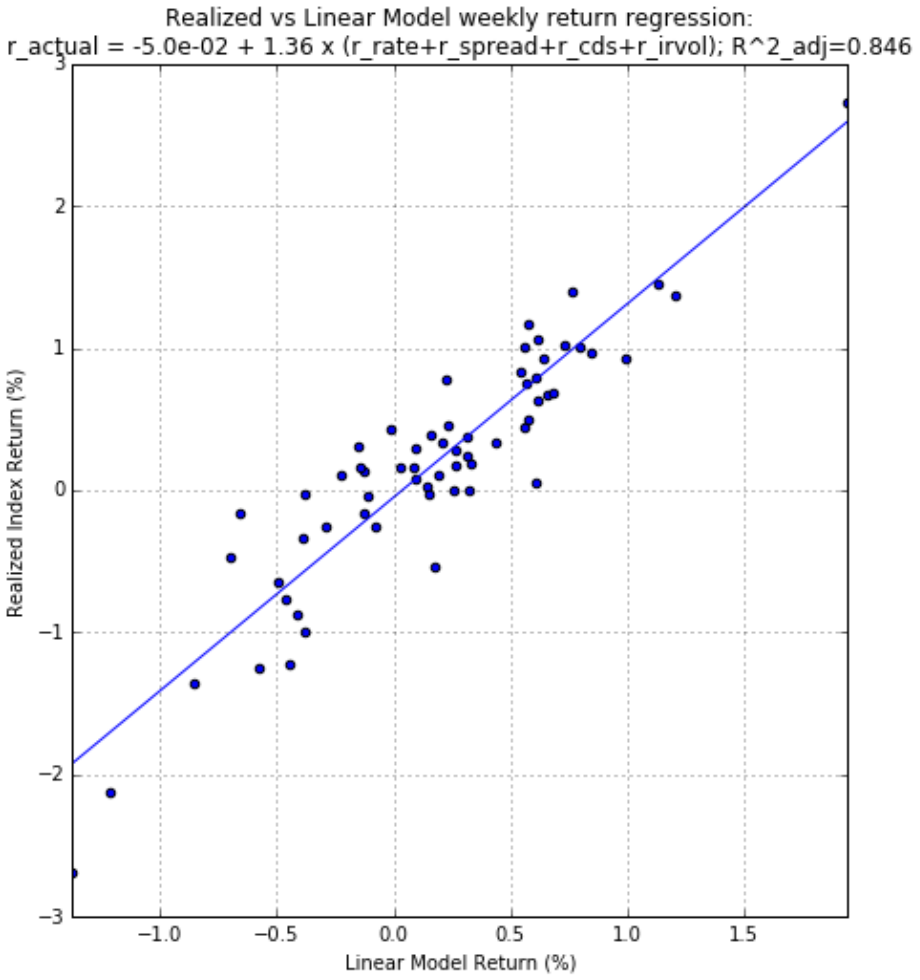
BASE CASE RISK CONTRIB (CDS - 52%; BS DISC – 48%)





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CONCLUSIONS

1. Coverage and quality of available risk factor data are important when deciding priorities among datasets

2. Coverage and quality depend on the use case and it affects risk forecast as much as risk settings does

3. Data on risk factor coverage for your portfolio can be obtained via simple reports. Analysis of alternatives requires setting up different data-priority waterfalls in tenant config file

4. Useful insights into risk forecast are obtained via a return analysis that will be soon available through a standard set of statistics and existing drilldowns

MSCI consultants and the Model Validation Research team can help you access this information for your specific portfolios

APPENDIX

Additional material

TOOLS FOR EVALUATION OF EX-ANTE RISK FORECAST

- Realized return: r_t
- Forecasted volatility: $\hat{\sigma}_t$
- $\bar{z} = \frac{1}{T}\sum_{t=1}^{T} z_t$
- Z-score*: $z_t = \frac{r_t}{\hat{\sigma}_t}$
- Bias statistic: $B = \sqrt{\frac{\sum_{t=1}^{T}(z_t - \bar{z})^2}{T-1}}$
- 95% Confidence Interval for B $\approx \left[1 - \sqrt{\frac{2}{T}}, 1 + \sqrt{\frac{2}{T}}\right]$

*In order to understand the core distribution, z-scores are censored to ± 4

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EXAMPLE OF QUALITY REPORT FOR DATASETS IN 2008

Data coverage scores of JPM CEMBI Index by Curve Type (2008)

CDS / Sector - Rating

Curve Type \ <Score>	Average of score_granularity	Average of score_historic	Average of score_staleness
JPM:BLEND-YIELD	5	0.14	0
MARKIT:CDS	0	0.46	0.12
MSCI:Sector/Rating	0	0.03	0

Issuer / Parent / Sector - Rating

Curve Type \ <Score>	Average of score_granularity	Average of score_historic	Average of score_staleness
JPM:BLEND-YIELD	5	0.07	0
ISSUER	0	0.63	0
MARKIT:CDS	0	0.67	0.33
MSCI:Sector/Rating	0	0	0

Parent / Sector - Rating

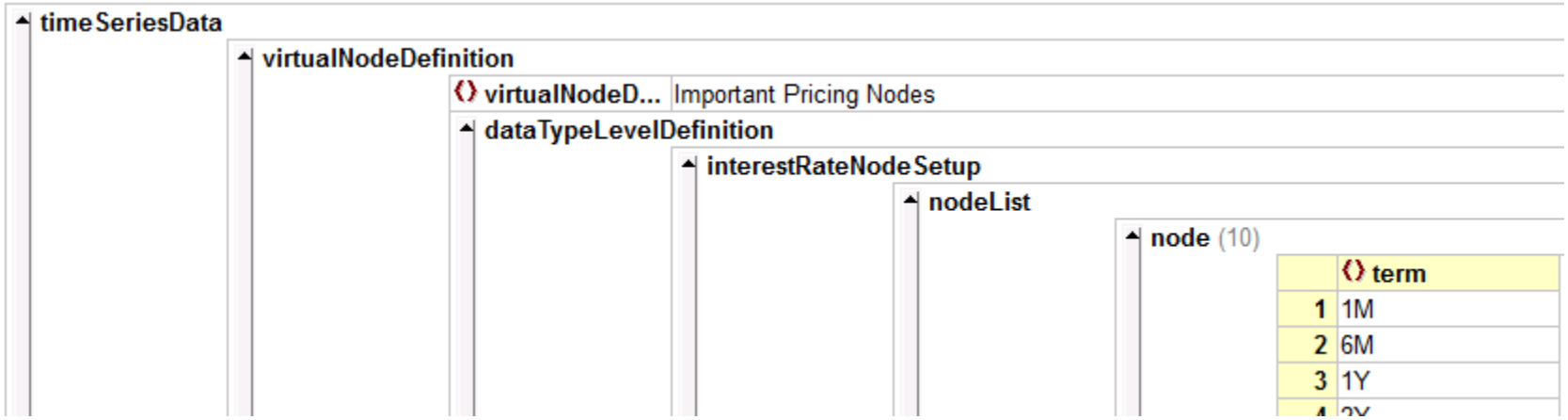
Curve Type \ <Score>	Average of score_granularity	Average of score_historic	Average of score_staleness
JPM:BLEND-YIELD	5	0.06	0
ISSUER	0	0.42	0
MARKIT:CDS	0	0.67	0.33
MSCI:Sector/Rating	0	0.02	0

Sector - Rating

Curve Type \ <Score>	Average of score_granularity	Average of score_historic	Average of score_staleness
JPM:BLEND-YIELD	5	0.06	0
MARKIT:CDS	0	0.67	0.33
MSCI:Sector/Rating	0	0.02	0

CREATING A WELL FORMATTED REPORT FOR RETURN DECOMPOSITION

- Different time series can have different terms structures. Discrepancies lead to technical complexities in building a well formatted time series reports
- **Virtual nodes** specifies a consistent node structure that Single Security Analytics like deltaEquivalents and Key-Rate-Durations require when generating the reports described in this presentation



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