BARCLAYS

Research

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POINT®: Mixed-frequency Models

and the Term Structure of Risk

July 2014

Agenda

- Mixed-frequency Risk Models
  - Daily
  - Weekly
  - Monthly
  - Annual
- Term Structure of Risk
- POINT risk model overview

Motivation

- Incorporate new and more high quality data into our models
- Update our models to reflect the current state of research
- More sophisticated models as better data become available
  - Higher-frequency data become available for more asset classes
  - Two-factor models to capture stylized facts
    - E.g., volatility clustering and mean-reversion
  - More responsive short-horizon forecast models
  - Mean-reversion more important for long-run forecasts
- Term structure of risk
  - Span the whole term structure of risk form daily to long-term horizons

Data

- We utilize daily, weekly and monthly data
- Available frequency depends on the liquidity of the underlying asset class
- As of July 2014, we have approximately 1,100 factors
  - Daily data are available for approximately 400 factors
    - E.g., developed market equity and fixed income, FX rates, commodities
  - Weekly data are available for approximately 700 factors
    - E.g., all factors that have daily data, as well as most of the credit factors and EM rates
  - All factors are available at the monthly frequency
    - Factors that do not have daily/weekly data include securitized factors and less liquid factors such as economic ones

Volatility Models

Decomposing the Covariance Matrix

$$\Sigma_t = D_t \times R_t \times D_t$$

$$D_t \sim diagonal\ volatility\ matrix$$

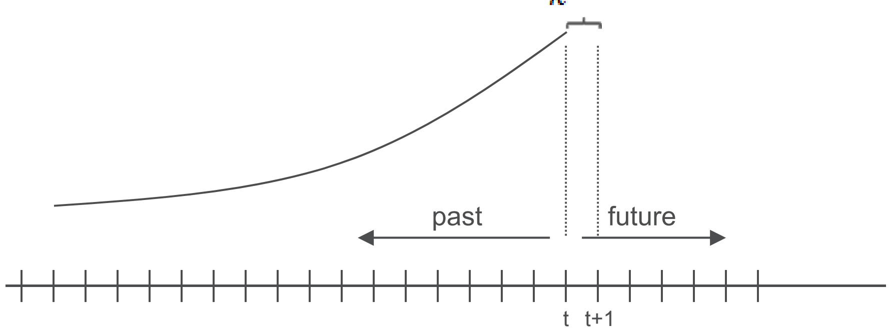
$$R_t \sim correlation\ matrix$$

Source: Barclays Research

- Separate properties into marginal and multivariate distribution
- More intuitive understanding of volatilities and correlations
- Better statistical models
  - Volatility models must be responsive
  - Correlations need more data to be precise

Volatility Models

$$\tilde{\sigma}^2_{t+1} = \sum_k w_{t-k} \times r^2_{t-k,t-k+1}$$



Source: Barclays Research

- Volatility models are weighting schemes (*w*) of past data
- Simple models
  - EWMA, unconditional, mowing-window
- Combine simple models
  - GARCH
- Models trade off responsiveness against precision

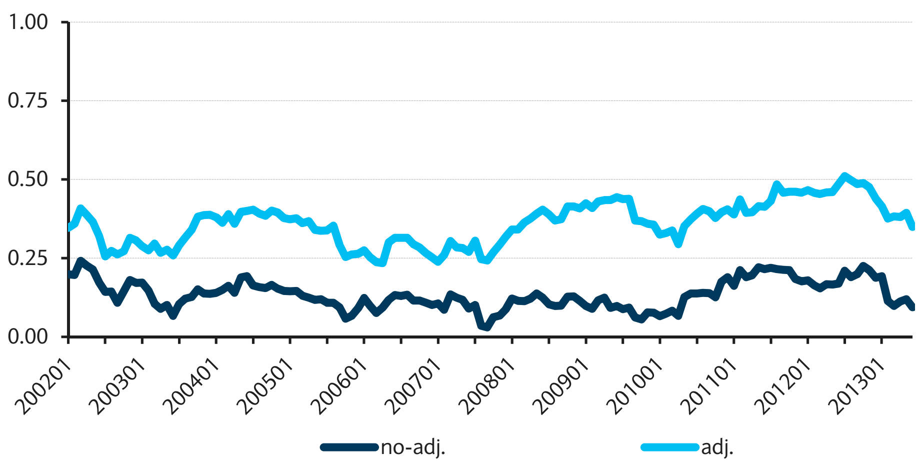
MXF Daily/weekly Models (Beta Version)

POINT – MXF Daily/weekly Models

Daily Model	Weekly Model

• Volatility Model
  • GARCH (1,1) with “skew-t” innovations
• Correlation Model
  • EWMA model with 125 days HL
  • Adjusted for non-synchronous trading bias (core model only)
• Daily (~400), weekly (~300) and monthly data
	• Volatility Model
	  • IGARCH(1,1) with “t” innovations
	• Correlation Model
	  • EWMA with 26 weeks HL
	  • No lead-lag adjustment
	• Weekly (~700) and monthly data

Non-synchronous Trading Bias: Correlations



Source: Barclays Research

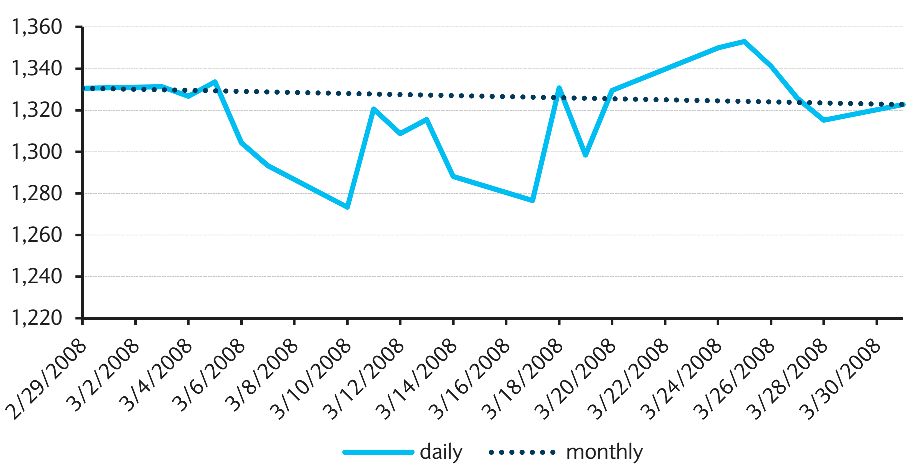
- Non-synchronous trading bias can be important for daily models
- Function of time difference b/w markets
- Example:
  - US Equity vs. JPY Equity
  - Correlation b/w US/JPY increases from ~10% to ~40% with adjustment

MXF Monthly Model (Beta Version)

Making Models more Responsive

- For short horizons, models should react quickly to changes in the market and economic environment
- Ways to make models more responsive
  - Condition on relevant information
    - DTS, CDP
  - Use higher frequency data
    - Mixed-frequency approach

S&P 500, March 2008



- Standard practice in risk management ignores information in observations within the risk horizon
- High-frequency data allow for improved responsiveness, greater precision, and robust estimation
- Monthly return: -0.60%
- Realized volatility (daily data): 8%

Source: Barclays Research

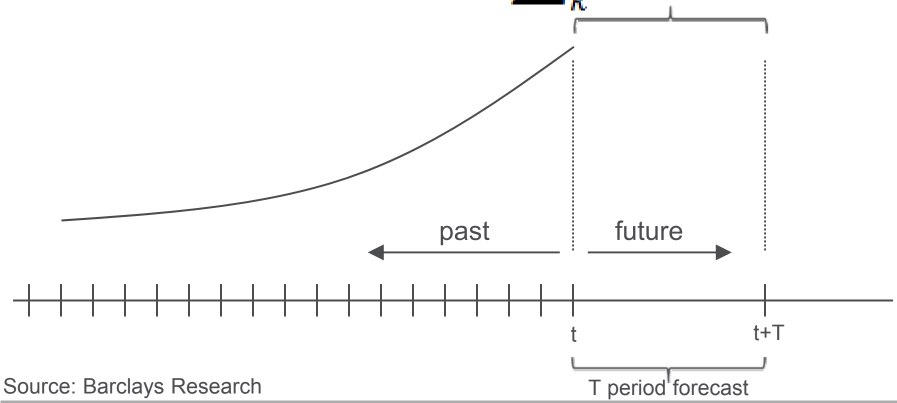
Volatility – Mixed-frequency Calibration

Mixed-frequency Calibration

- Higher-frequency observations are used to model lower-frequency properties
  - Example: Use daily data to forecast monthly volatility
  - Breaks the responsiveness vs. precision trade off
  - Mixed frequency data sampling (MIDAS) – Ghysels and co-authors
- Very flexible approach
  - Model can be extended to many different settings/frequencies
  - Frequency used changes across asset classes depending on liquidity

Using higher frequency data

$$\tilde{\sigma}^2_{t+T} = \phi \sum_k w_{t-k} \times r^2_{t-k,t-k+1}$$



Source: Barclays Research

- ***w*** is a weighting scheme (EWMA, MW) on high frequency data
- **Φ** is the scaling parameter to transform the high frequency model into a low frequency forecast
  - Depends on serial correlation

POINT – Mixed-frequency Calibration (MXF)

$$\boxed{\tilde{\sigma}^2_{T+1} = \underbrace{\phi}_{scaling} \times \underbrace{\left(\lambda \times \tilde{\sigma}^2_{short-run,T} + (1-\lambda) \times \tilde{\sigma}^2_{long-run,T}\right)}_{high-frequency\ vol\ model}}$$

High-frequency Volatility Model

- Two factor model
- Short-run component
  - EWMA with 42 day/13 week HL
- Long-run component
  - 2-year MW
- λ is relative weight b/w long- and short-run component

Scaling

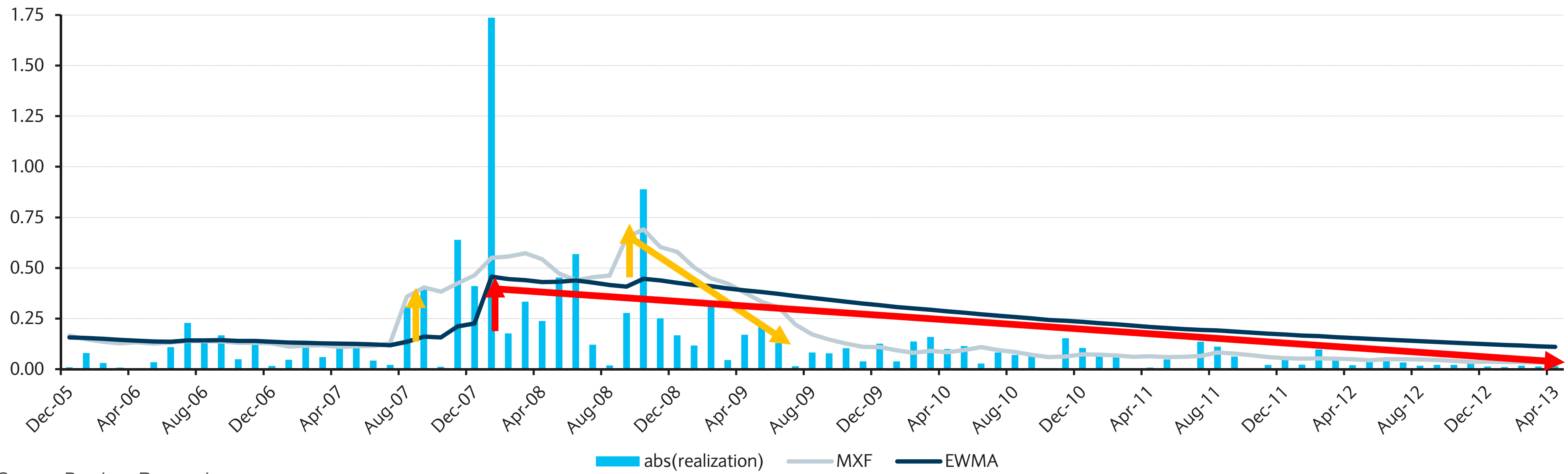
- High-frequency volatility has to be scaled to low-frequency forecast
- Need additional parameter to scale daily/weekly volatility to monthly volatility
  - Φ is scaling parameter
  - Mainly accounts for serial correlation

POINT – MXF Correlation Model

- MXF correlation model based on weekly data
  - EWMA model with 52 weeks HL
  - Adjusting for cross serial correlation: Newey-West method

Mixed-frequency Calibration vs. EWMA

6-month US Treasury



Source: Barclays Research

EWMA

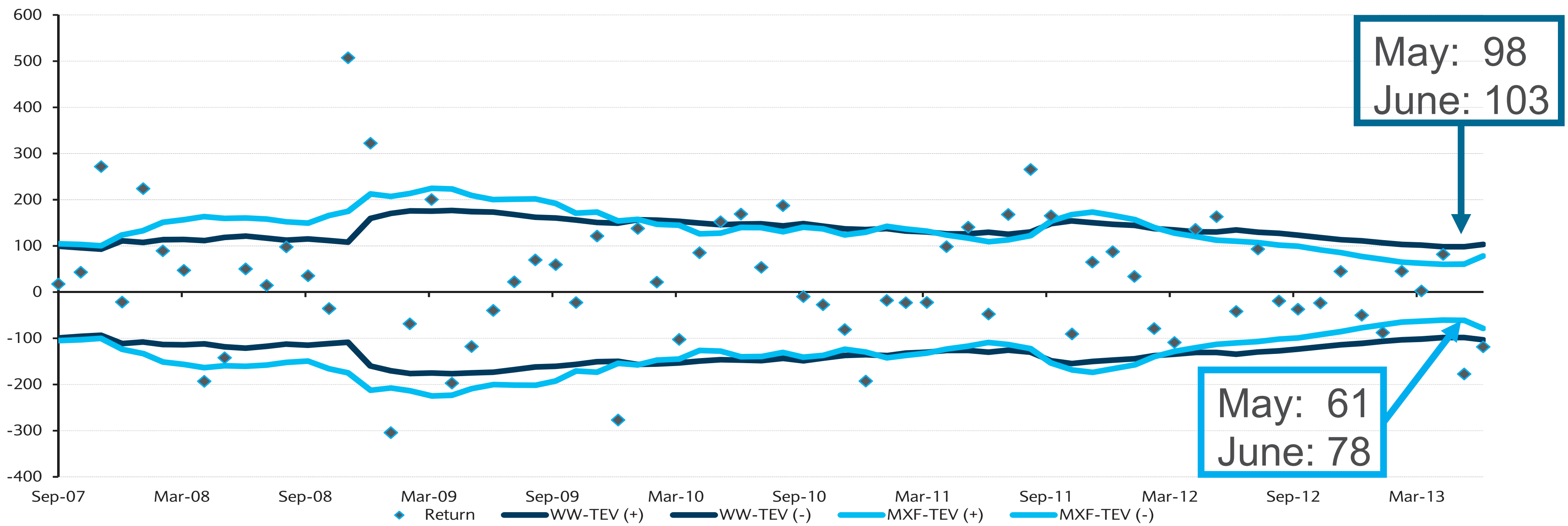
- EWMA adjusts fast to rapid increases in volatility
- EWMA needs a long time to mean-revert after volatility spikes
- No intra-period information
- Trade-off between responsiveness and precision

MXF

- MXF allows for volatility forecasts to accurately track
  - Jumps in volatility
  - Fast mean-reversion after volatility spikes
- Intra-period information
- Very responsive model

Monthly MXF – US Treasury Index

Monthly MXF vs. EWMA



Source: Barclays Research

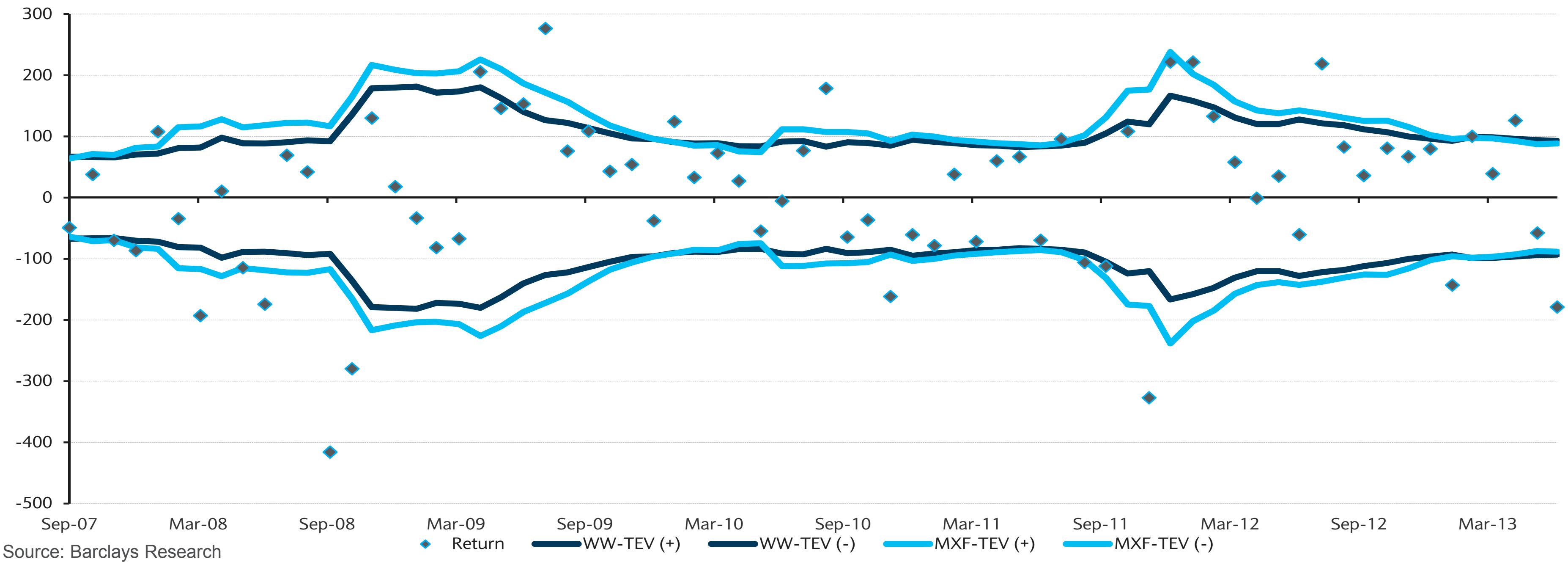
Statistics of Standardized Returns

	Stand. Dev.	Skew	Ex. Kurt.	Min	Max
Weighted	1.09	1.00	3.30	-1.85	4.68
MXF	1.02	0.00	1.00	-2.92	2.90

Source: Barclays Research

Monthly MXF – Euro Credit Index

Monthly MXF vs. EWMA



Source: Barclays Research

Statistics of Standardized Returns

	Stand. Dev.	Skew	Ex. Kurt.	Min	Max
Weighted	1.22	-1.00	1.70	-4.52	2.19
MXF	1.01	-0.90	1.00	-3.56	1.66

Source: Barclays Research

MXF Annual Model (Beta Version)

POINT Approach: Qualitative Criteria + Quantitative Model

Annual Volatility Approach

Long-term volatility forecasts should

- be responsive, but **smooth**
- **mean-revert** over the long run
- more **stable** than short-term forecast

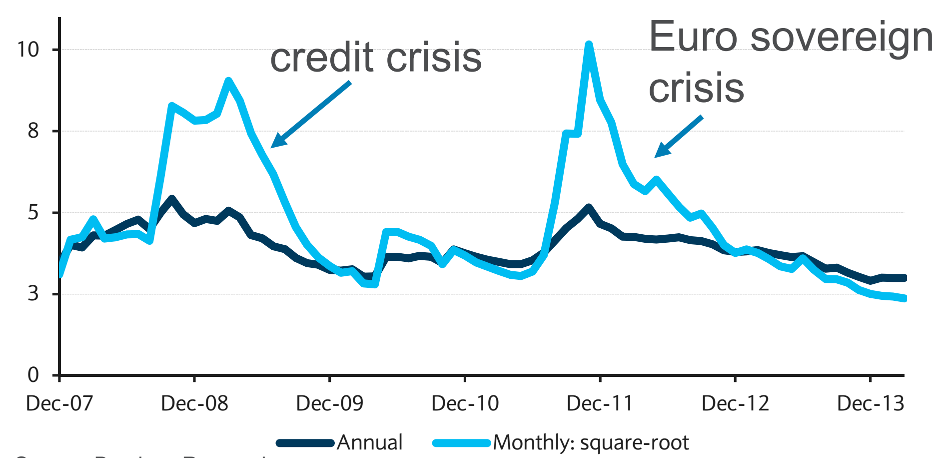
Empirical Facts

- Volatility spikes mean-revert fast
  - Smooth out volatility spikes
  - Annual forecast is more stable than short-term forecast
- Volatility can remain at very low levels for extended periods of time
- Mean-reversion is state dependent

Model Features

- **Two-factor model**
  - Short-run component moves around a long-run component
- **Mean-reversion** depends on deviation b/w short- and long-run component
- **Long-run correlation model** adjusting for cross-serial correlation

EUR Credit: Annual vs. Scaled Monthly



Source: Barclays Research

Term Structure of Volatility

Quantitative Two-Factor Volatility Model

$$\hat{\sigma}_{t,t+1y}^{annual} = \hat{\sigma}_{t}^{long-run} \times \left(1 - \theta_{t,t+1y}\right) + \hat{\sigma}_{t}^{short-run} \times \theta_{t,t+1y}$$

Volatility Model	"Intuitive" Quantitative Model

Volatility Model

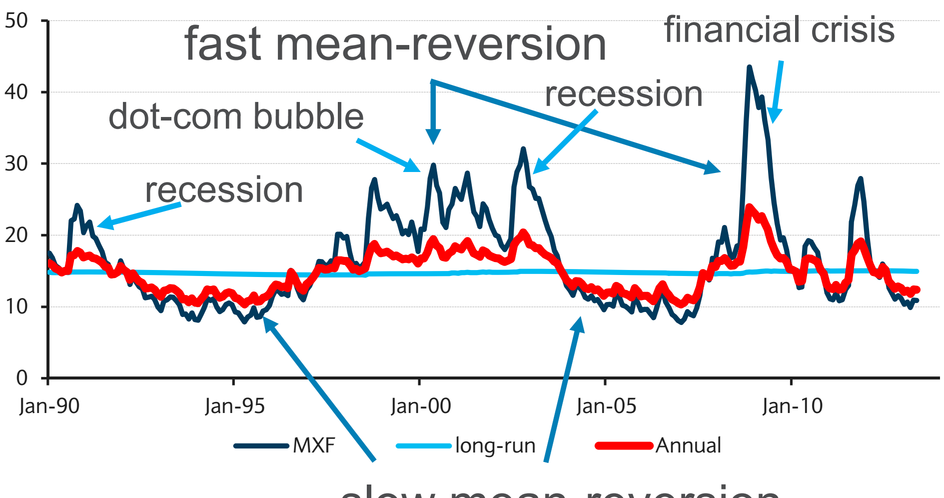
- Two-factor model
  - Short-run component moves around a long-run component
- Relative weights
  - Time varying and state dependent
  - Capture mean-reversion
    - Speed of mean-reversion depends on short- to long-run deviation

"Intuitive" Quantitative Model

- Model the term structure of volatility
  - Mean-reversion is calibrated via a simplified Nelson-Siegel term structure model
- Historical data to calibrate the model
- Economic intuitive model that obeys stylized facts

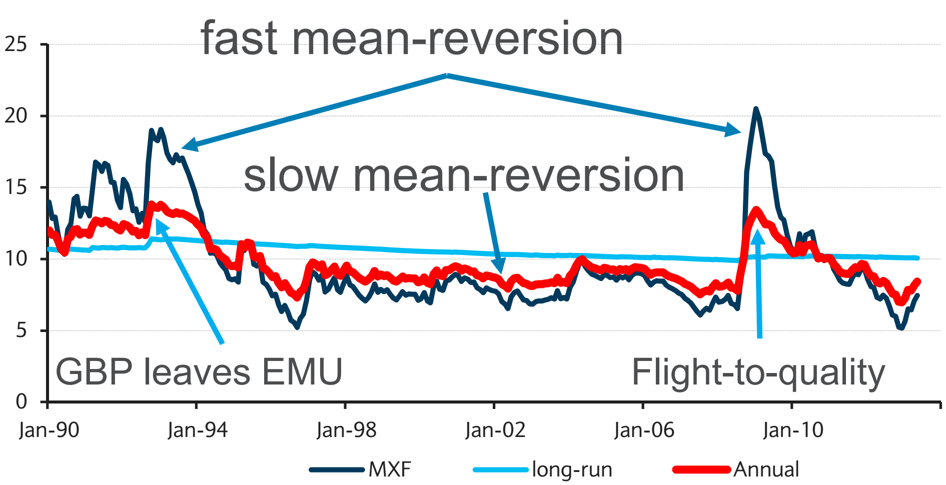
POINT Annual Volatility Model

US Equity



Source: Barclays Research

FX USD-GBP



Source: Barclays Research

- Annual volatility forecast more stable than monthly forecast
  - Volatility spikes are smoothed
  - Fast mean-reversion
- During very low volatility periods, annual forecast mean-reverts slowly to higher levels
- Mean-reversion is state and factor dependent
  - Market-wide events:
    - Financial crises
    - Recessions
  - Factor-specific events:
    - E.g.: GBP leaving EMU

Annual Model: Loadings*

- Global Risk Model (GRM) is a linear factor model

$$R = L \times F \Rightarrow \sigma_R = L \times \sigma_F$$

- Short-run volatility spikes affect factor volatility
  - Mean reversion for the long run (LR) model allows smoother reaction
  - Discussion so far

$$\sigma_F \longrightarrow \sigma_F^{LR}$$

- However, for some other factors volatility spikes also affect their loadings
  - E.g., loadings that depend on spread levels: BiDS**, DTS
  - Spreads also mean-revert over the long run

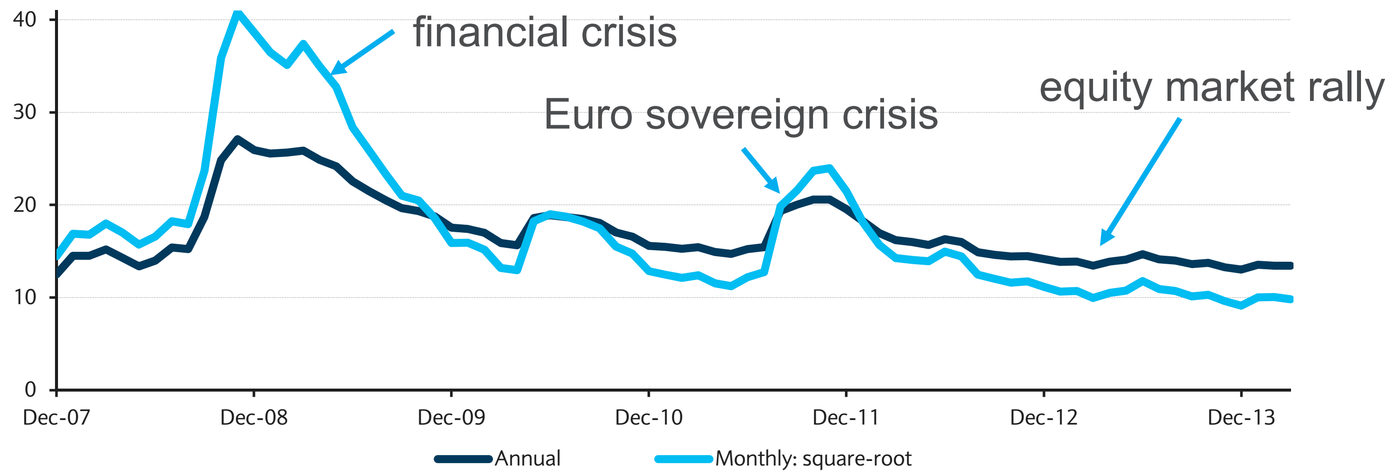
$$L = L(S) \longrightarrow L^{LR} = L\left(S^{LR}\right)$$

* Schuehle, 2014, POINT Annual Risk Model – Term Structure of Risk, Barclays presentation

* * Gu and Silva, 2014, Enhanced Credit Betas, Barclays presentation

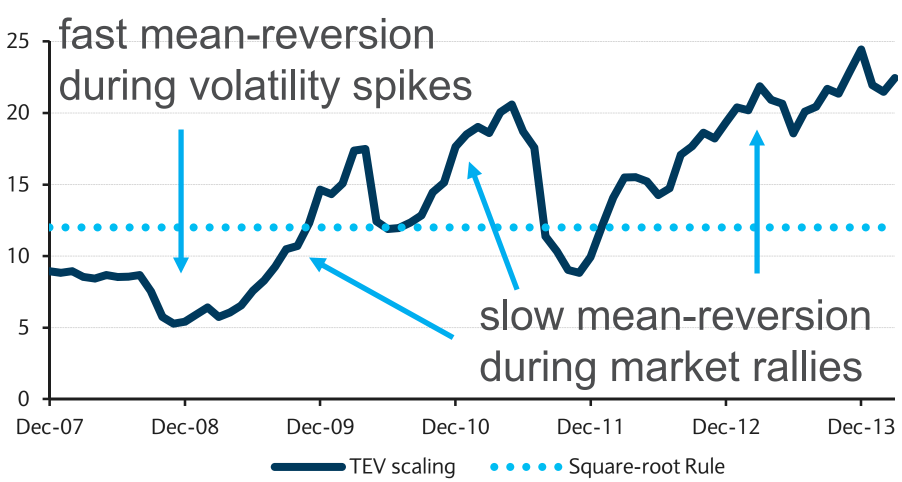
Annual Model: S&P 500 Index

Annual vs. Monthly



Source: Barclays Research

TEV Scaling: Annual vs. Monthly



Source: Barclays Research

Comparison: TEV

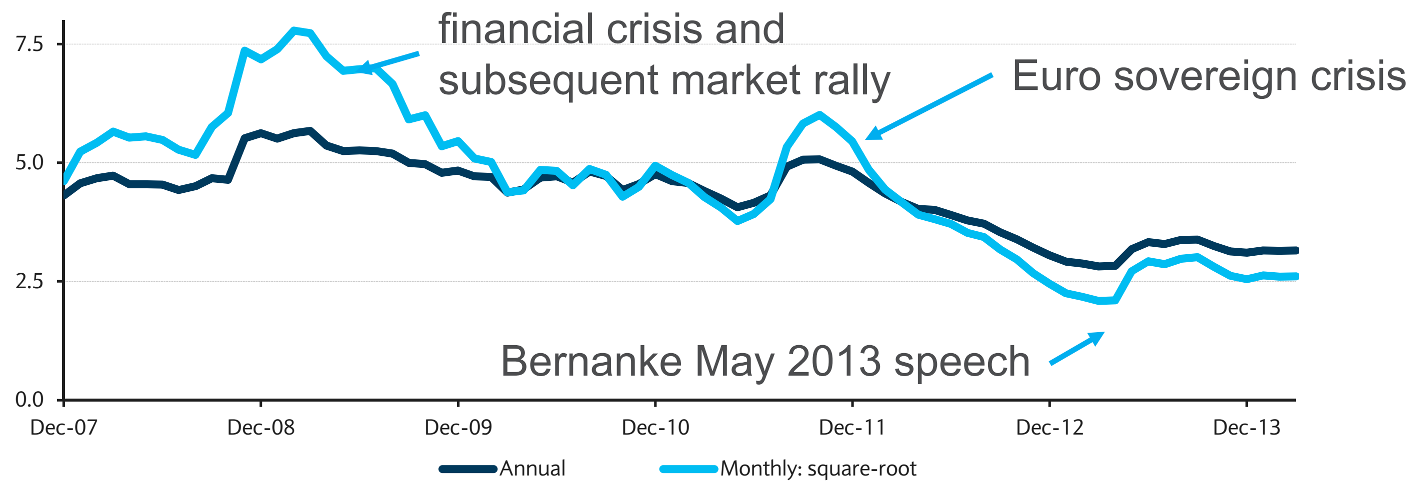
Volatility	Annual	Monthly (scaled)
Min	12.5%	9.1%
Max	27.1%	40.8%
Std.Dev (Vol-of-vol)	3.7%	7.9%

Source: Barclays Research

- Scaling ranges between 5.3 and 24.4
- Average scaling over time 14.1

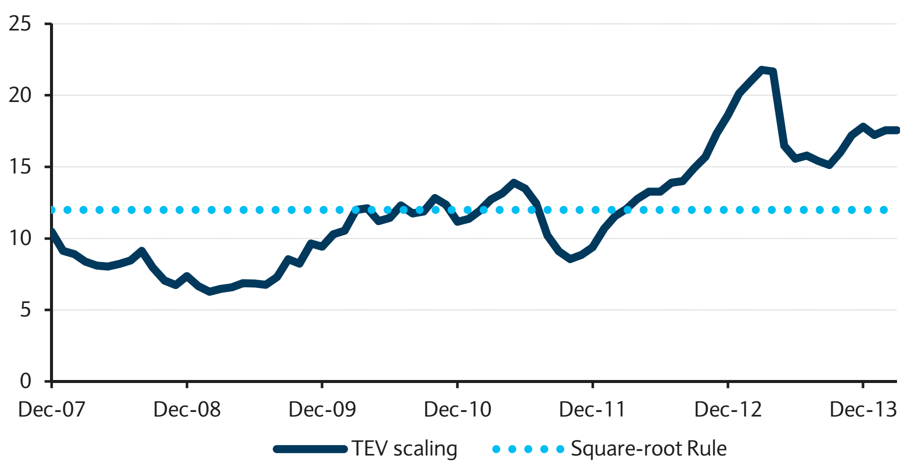
Annual Model: US Treasury Index

Annual vs. Monthly



Source: Barclays Research

TEV Scaling: Annual vs. Monthly



Source: Barclays Research

Comparison: TEV

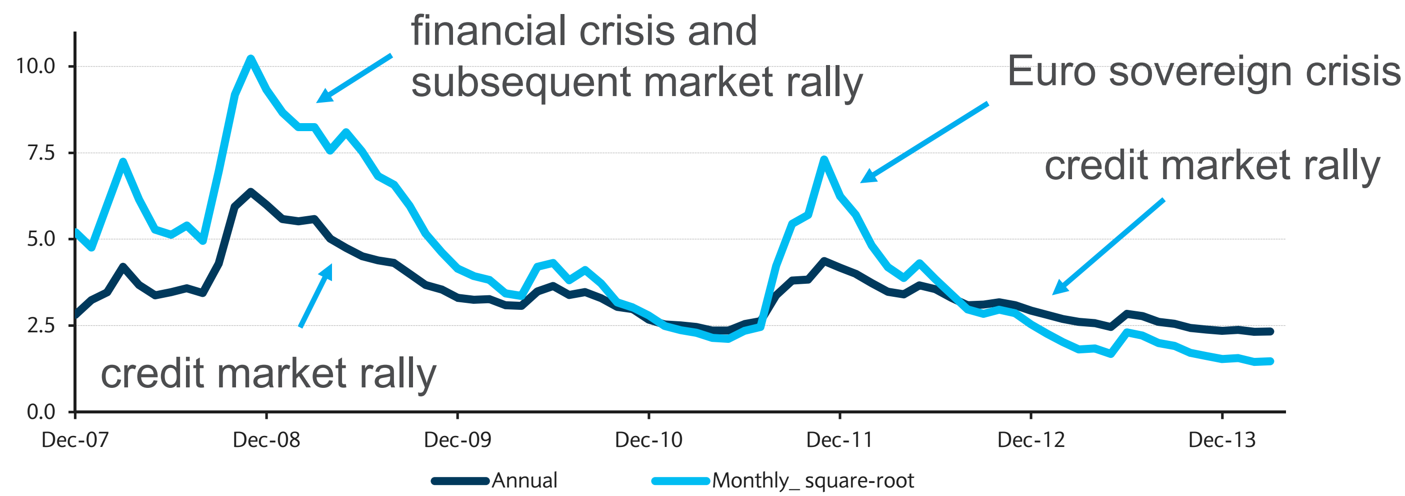
Volatility	Annual	Monthly (scaled)
Min	2.8%	2.1%
Max	5.7%	7.8%
Std.Dev (Vol-of-vol)	78bp	152bp

Source: Barclays Research

- Scaling ranges between 6.3 and 21.8
- Average scaling over time 11.9

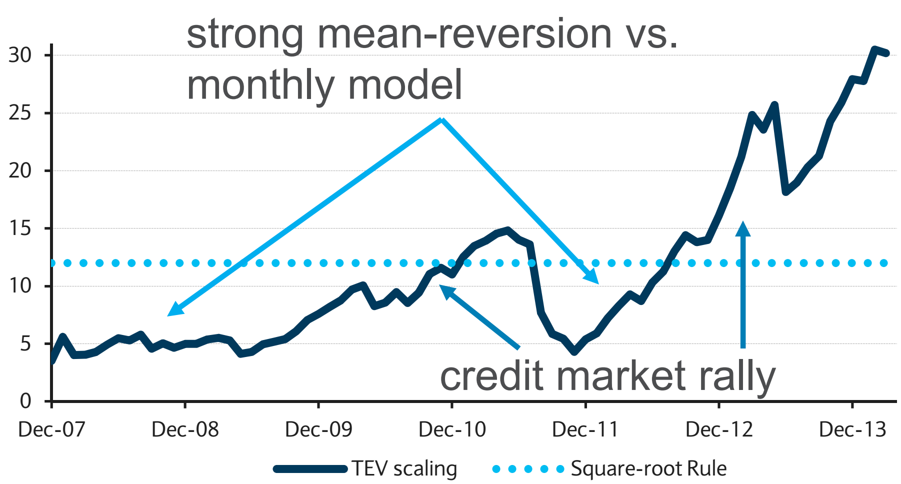
Annual Model: US Credit Corp Index Yield Curve Hedged

Annual vs. Monthly



Source: Barclays Research

TEV Scaling: Annual vs. Monthly



Source: Barclays Research

Comparison: TEV

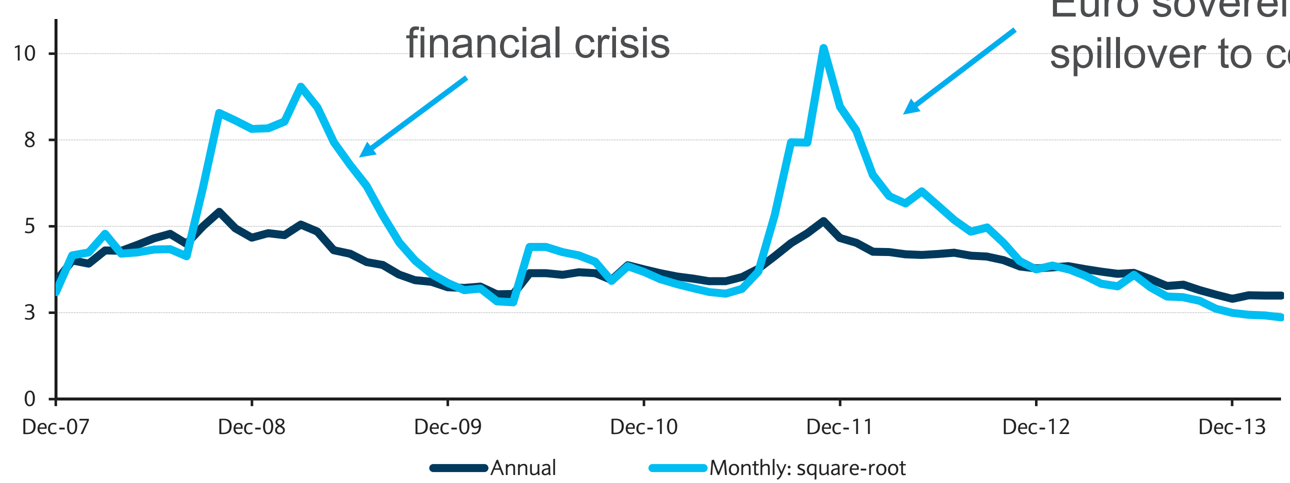
Volatility	Annual	Monthly (scaled)
Min	2.3%	1.5%
Max	6.4%	10.2%
Std.Dev (Vol-of-vol)	95bp	222bp

Source: Barclays Research

- Scaling ranges between 3.5 and 30.5
- Average scaling over time 11.3

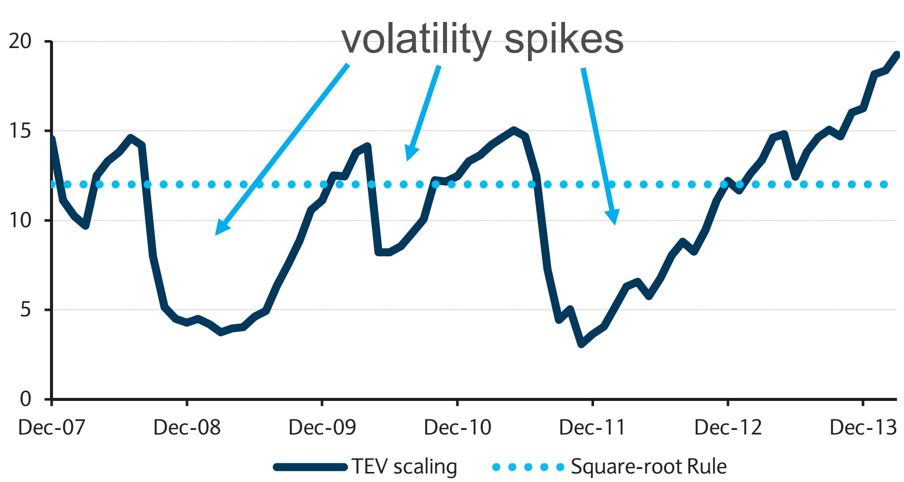
Annual Model: Euro Credit Corp Index

Annual vs. Monthly



Source: Barclays Research

TEV Scaling: Annual vs. Monthly



Source: Barclays Research

Comparison: TEV

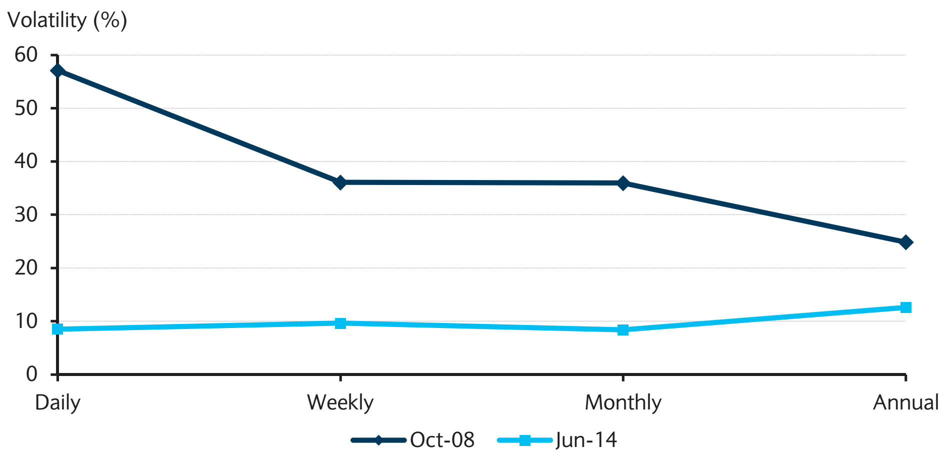
Volatility	Annual	Monthly (scaled)
Min	2.9%	2.4%
Max	5.4%	10.2%
Std.Dev (Vol-of-vol)	60bp	188bp

Source: Barclays Research

- Scaling ranges between 3.1 and 19.2
- Average scaling over time 10.3

Term Structure of Risk

S&P 500 Index (annualized)



Source: Barclays Research

Term Structure of Risk

- Both level and shape change over time
- To calibrate the annual model we use the information contained in the term structure of risk
- We are planning to further extend the forecast horizon

MXF Forecasts (bps): June 2014

Index	Daily	Weekly	Monthly	Annual
US Treasury	15.6	40.5	70.9	306.9
US Credit Corp	20.9	57	96.5	362.9
US Agg	15.8	41.4	72.2	303.3
S&P 500	53.8	134	241.9	1259.2
EUR Treasury	20.9	36.4	76.5	344.6
EUR Agg	16.8	29.2	67.4	306.7

Source: Barclays Research

Current Risk Levels

- We are currently in a low-volatility environment
- Annual volatility forecasts are substantially higher than short-term forecasts
  - Increasing term structure of risk

Conclusion

- Mixed-frequency models are our flagship models
- Term structure of risk
- Mixed-frequency suite of models contains several forecast horizons
  - Daily
  - Weekly
  - Monthly
  - Annual
- We will remove the “beta-label” with the September release
- We continue to support the weighted and unweighted models in POINT

Risk Models in POINT

Model	Daily	Weekly	Monthly	Annual
Mixed-frequency	✓	✓	✓	✓
Weighted	✓*		✓	
Unweighted			✓	

* To be discontinued soon

Source: Barclays Research

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