The Actuarial Profession
making financial sense of the future

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Macroeconomic Scenarios
A Frequency Domain Approach

Much decision making takes economic scenario generation (ESG) as input

Current or planned use of economic capital and related measures

Extent of use of EC within application	Strategic planning	Capital manage-ment	Risk appetite	Limit setting	Strategic asset allocation	Hedging	Bonus crediting policy	Pricing and product design	Reinsur-ance purchase decision	M&A	Target setting	Compen-sation	External commu-nication
Major decision factor	4	4	6	4	4	4		2	5		4		2
One of the elements considered	12	14	12	12	14	11	7	12	10	13	11	7	15
Considered but not a major influence	1			1		1	4	3	2	4	2	5	1
Not used	1					2	7	1	1	1	1	6	

Source: CEIOPS (2009)

Many uses = many time horizons

Source: Varnell (2009)

- 6.6.9 ... it is useful to have a common set of real world ESG scenarios used throughout the enterprise, against which all decisions would be based. This can put a lot of demand on the ESG model to capture many features ...
- 6.6.10 If the ESG model cannot capture enough of the features of the economy ... this would ... increases the risk of inconsistent decisions being taken ...
- 6.23.8 Knowing the distribution of an economic variable at a single time horizon is not sufficient to understand how the distribution evolves at different time horizons.
- 6.23.9 If the ESG model [is] only calibrated to a specific time horizon, then poorly calibrated risk measures may result if a different time horizon is used ...
- 6.23.10. A well designed and well calibrated ESG model provides a sound approach to aggregating a short-term distribution of economic variables to a longer-term distribution of those same economic variables.

Some criteria to be met for good (real world) ESG

- Term structure of risk and return
  - Risk and return properties such as means, volatilities, correlations and distributions vary with the investment horizon
- Business cycle dynamics
  - Business cycle behavior is of all times and all variables and features specific and well known (lead-lag) relations
- Volatility dynamics
  - Volatility itself is volatile and features dynamics and correlations
- Tail risk
  - Correlations increase in the left tails of the distributions
- Non-normal distributions
  - Distributions typically do not resemble the Normal distribution
- Yield curve dynamics
  - Volatilities, parallel shift, tilt and flex movements

The number one challenge for (real world) ESG

- Capturing all these empirical features of economies and financial markets simultaneously

- Thereby providing one consistent ESG to support all decision making in areas of strategy, implementation and monitoring
  - Multi-horizon: Decades, years, months
  - Multi-frequency: Years, quarters, months
  - Multi-dimensional: Few, dozens, hundreds

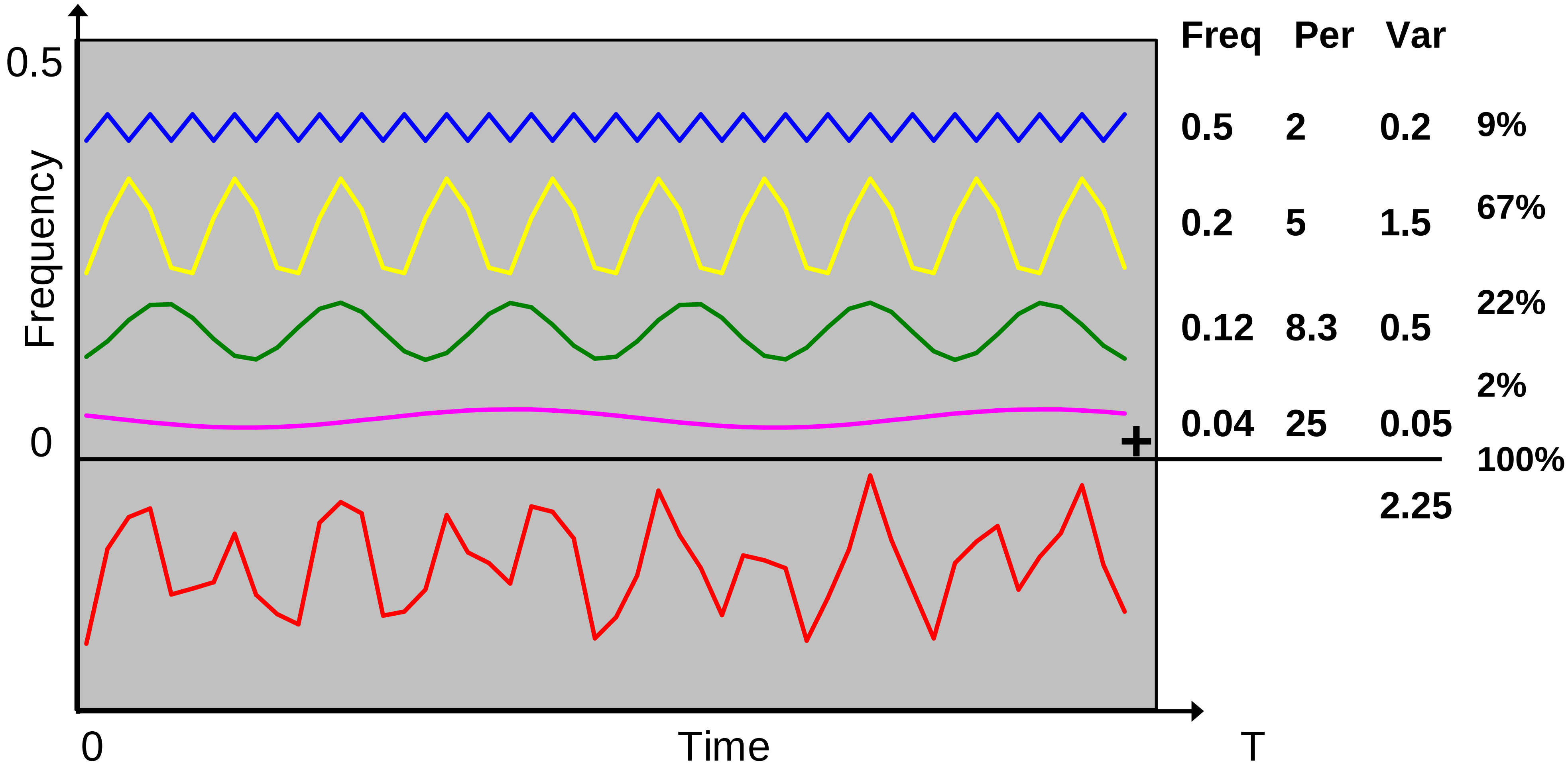
- Scenarios of crucial importance because they have large impact on model outcomes and thereby on decisions

Frequency domain approach

- Achieving these strong ESG ambitions requires an optimal mix of multiple techniques

- Here we describe and motivate a central frequency domain methodology for time series modeling as proposed in Steehouwer (2005) which consists of the following steps
  1. Time series decomposition
  2. Time series analysis
  3. Model specification and estimation
  4. Model analysis (not included)

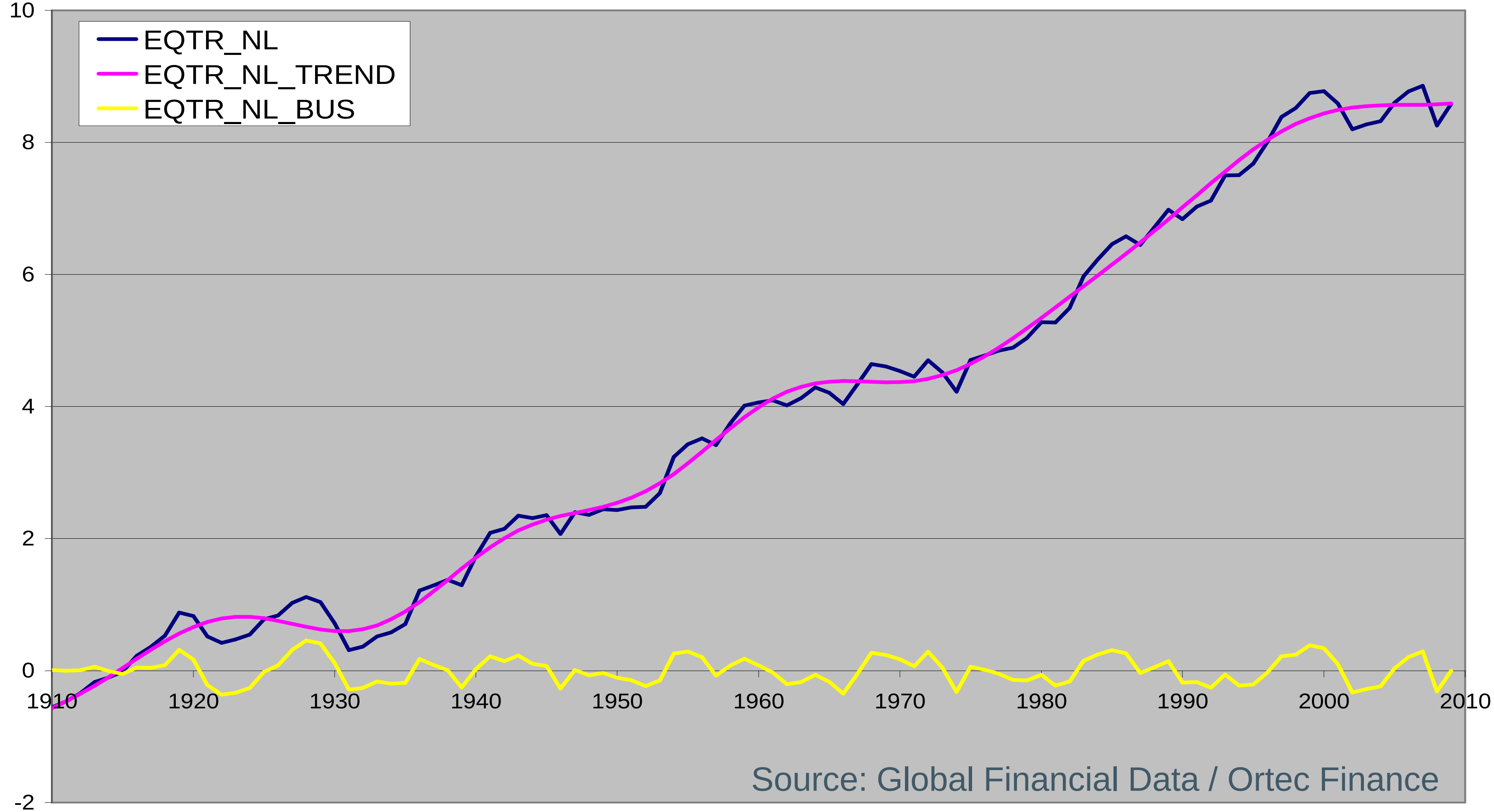
Time domain versus frequency domain



- Application 1: Decomposing time series = Filtering
- Application 2: Decomposing variance = Spectral analysis

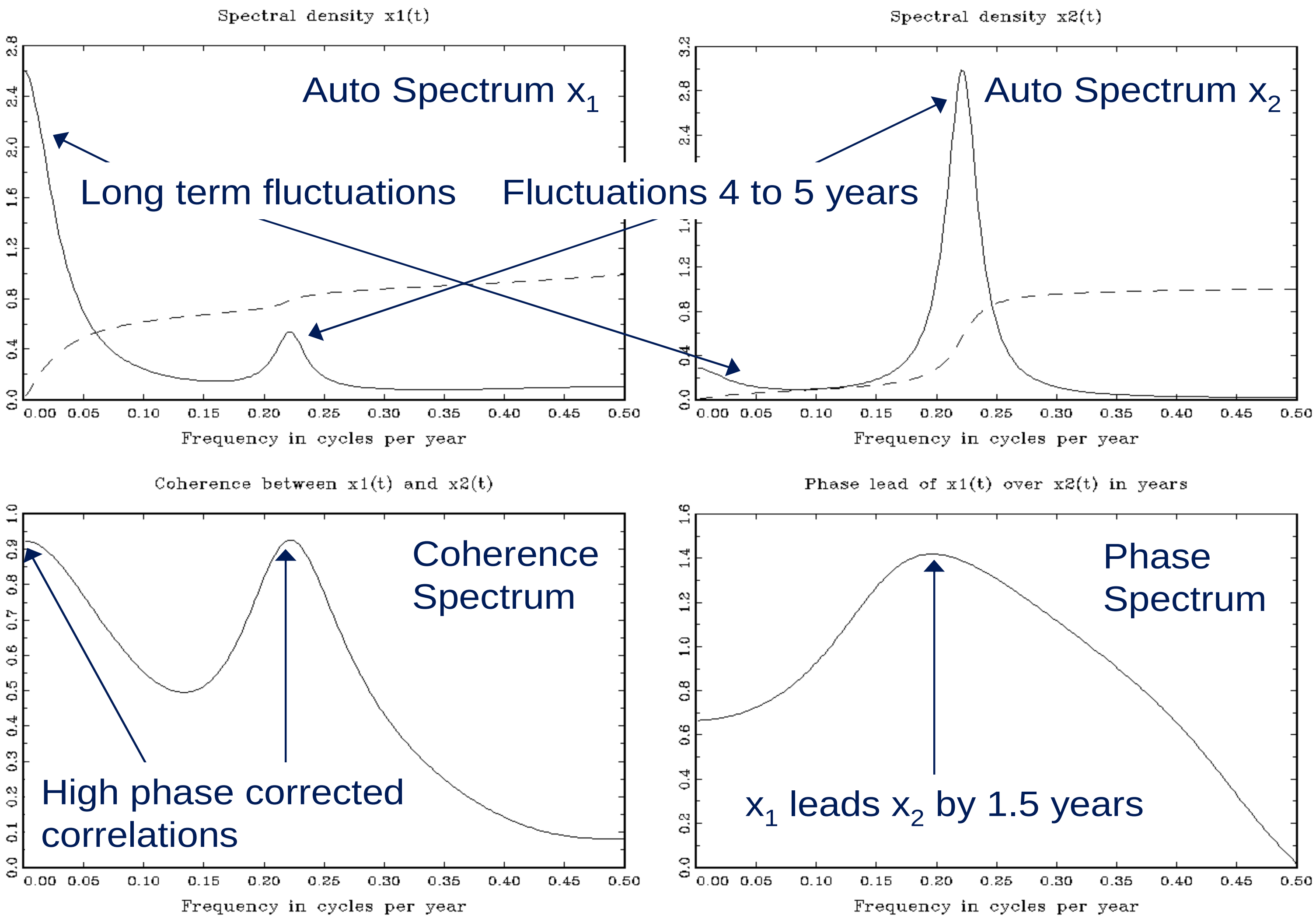
1. Time series decomposition

Log stock total return index NL



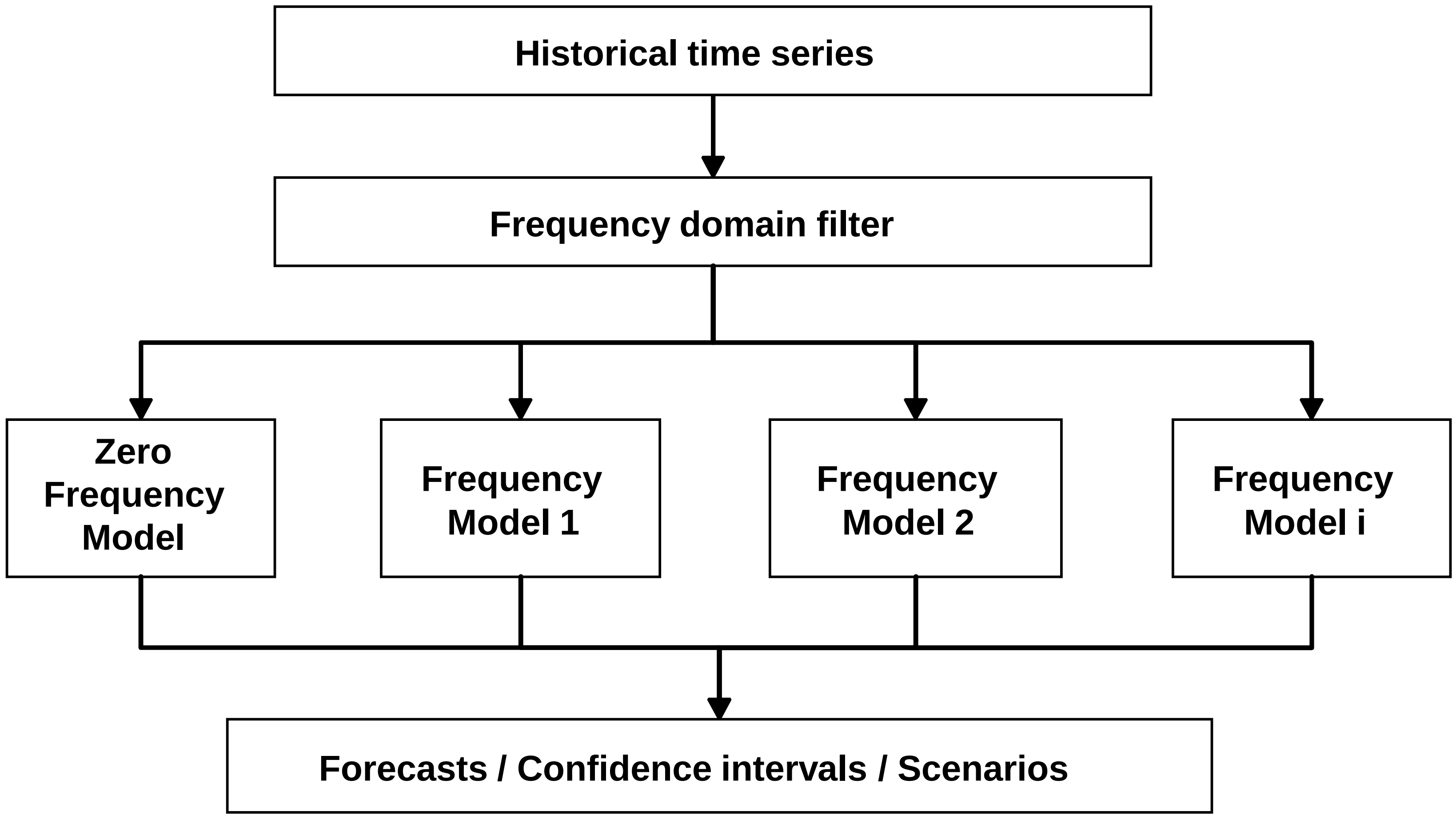
- Decompose time series by using appropriate filtering techniques
- Analyze and model these (orthogonal) components separately
- Here, trend and business cycle components

2. Time series analysis



- Unravel frequencies with appropriate spectral analysis techniques
- For example business cycle lead - lag relations

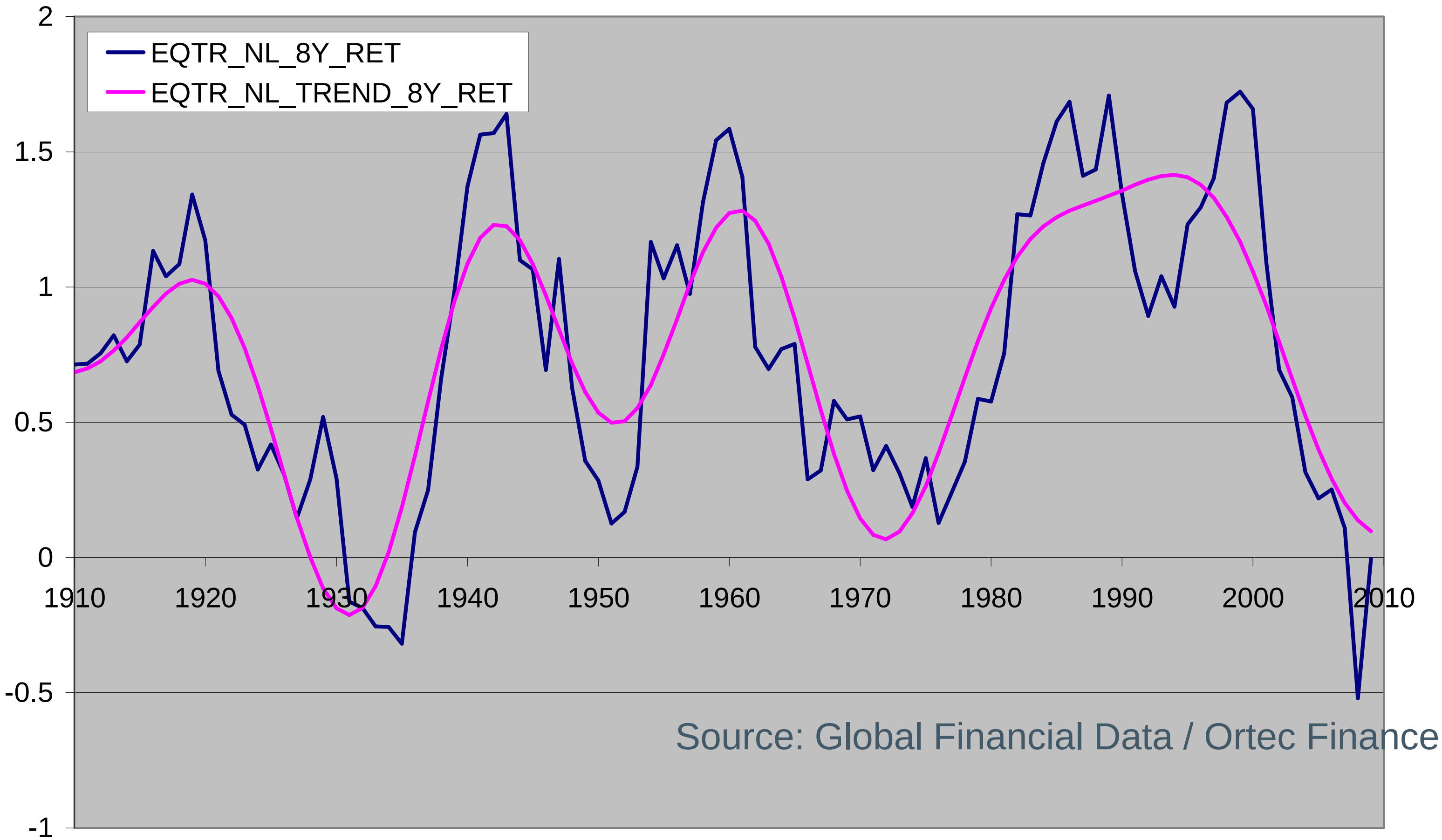
3. Model specification and estimation



- Different models for special zero frequency and other frequency bands
- Different samples and data frequencies (“mixed frequency models”)
- Orthogonal property of decomposition used for combining models

Long term returns

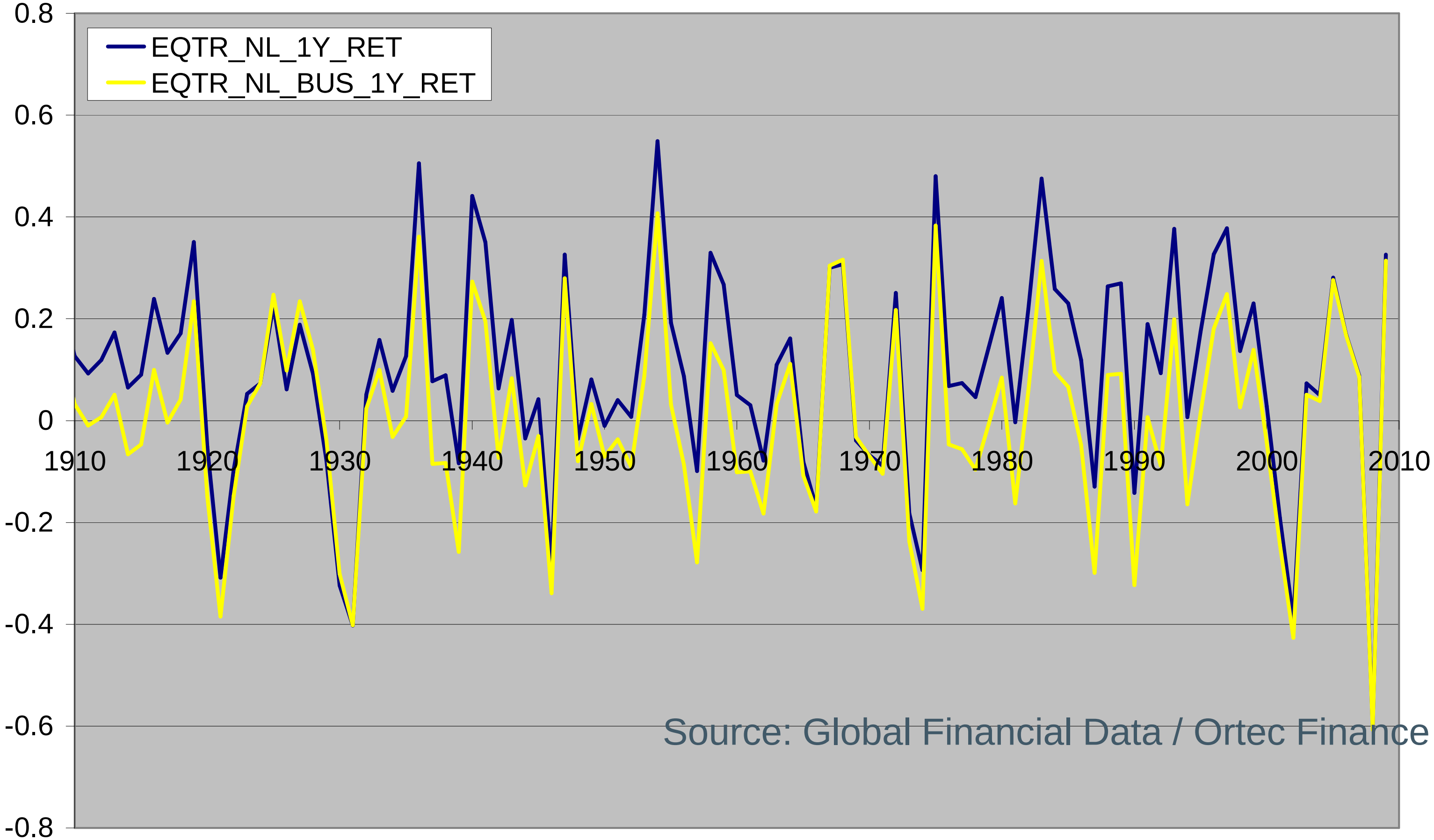
8 annual NL stock log returns



- Long term features based on long term returns...

Medium term returns

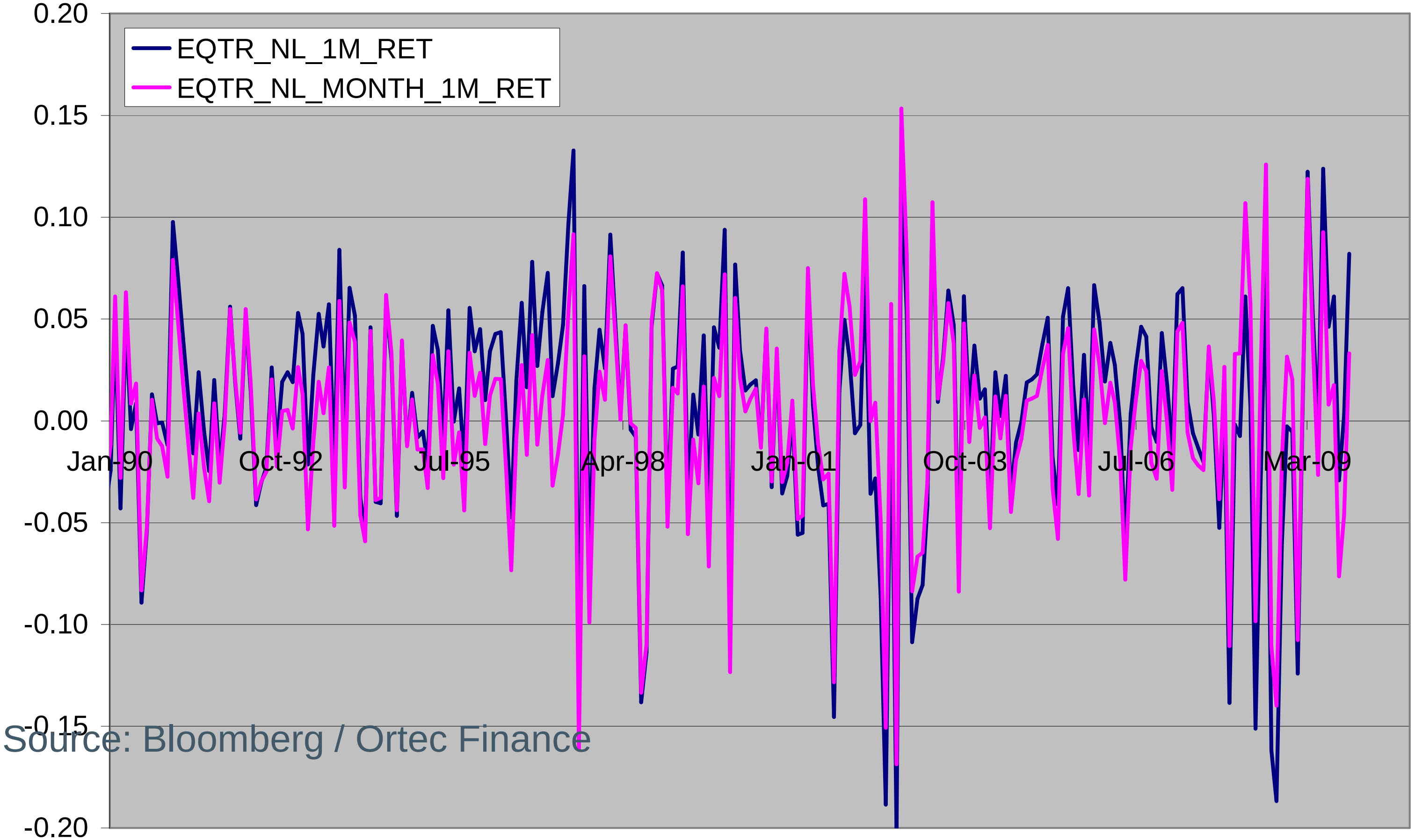
Annual NL stock log returns



- ...medium term features based on medium term returns...

Short term returns

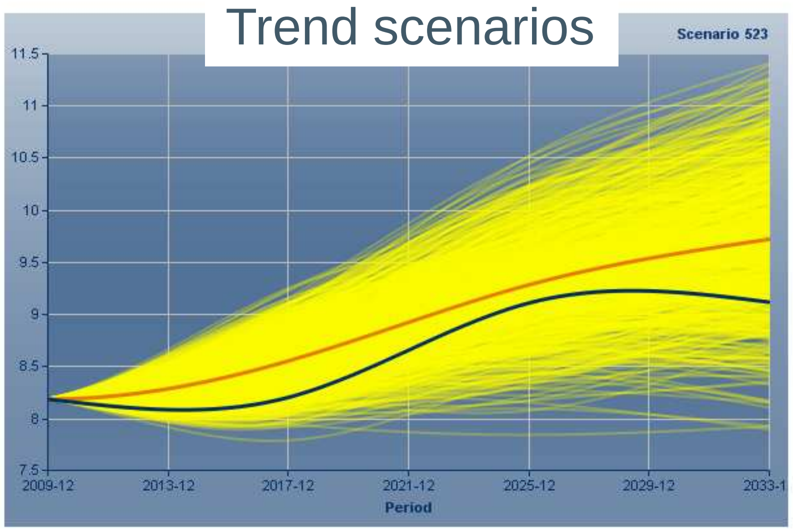
Monthly NL stock log returns

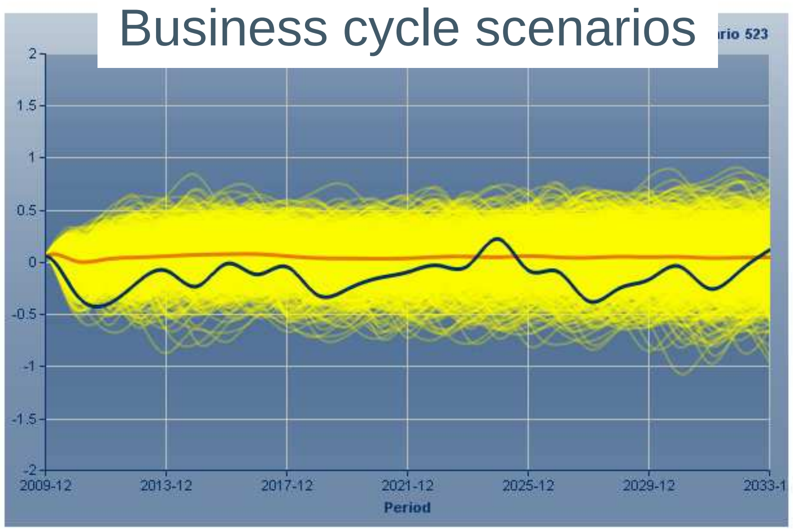


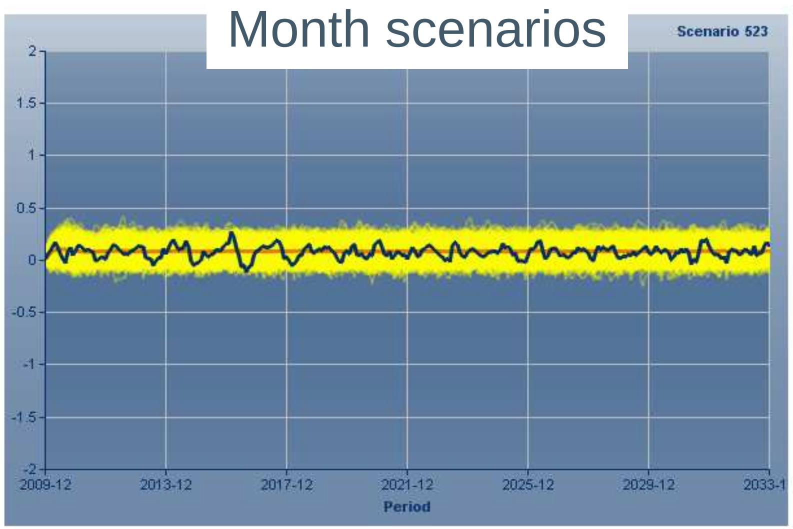
Source: Bloomberg / Ortec Finance

- ...short term features based on short term returns...

Scenarios: Log stock total return index US

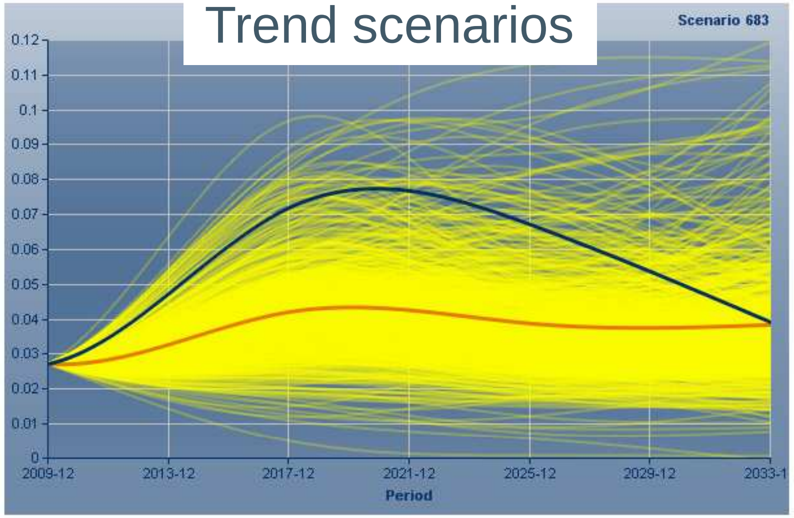


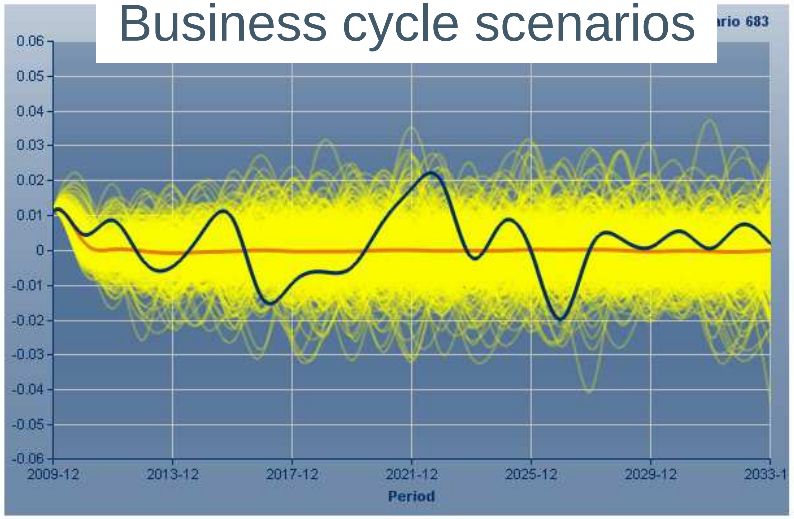


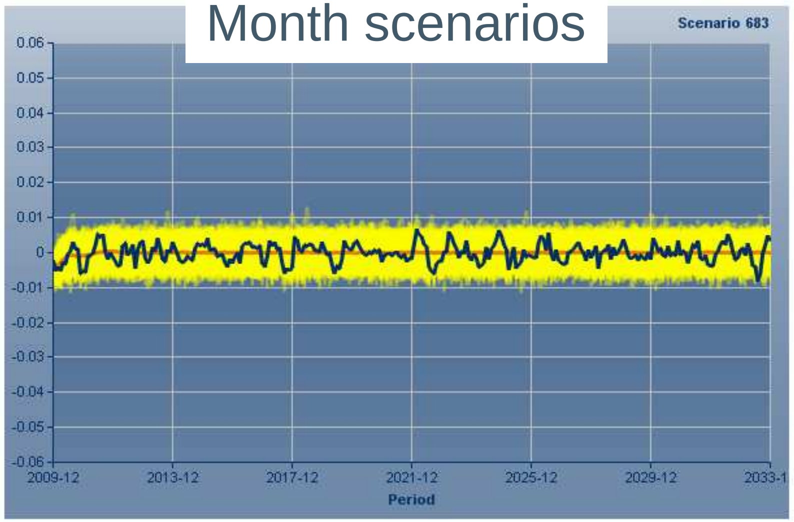


- ...and combine long, medium and short term returns.

Scenarios: 10 year government bond yield US







Motivation - I

1. Understanding data and model dynamics: Powerful tools for understanding dynamics of historical time series and models

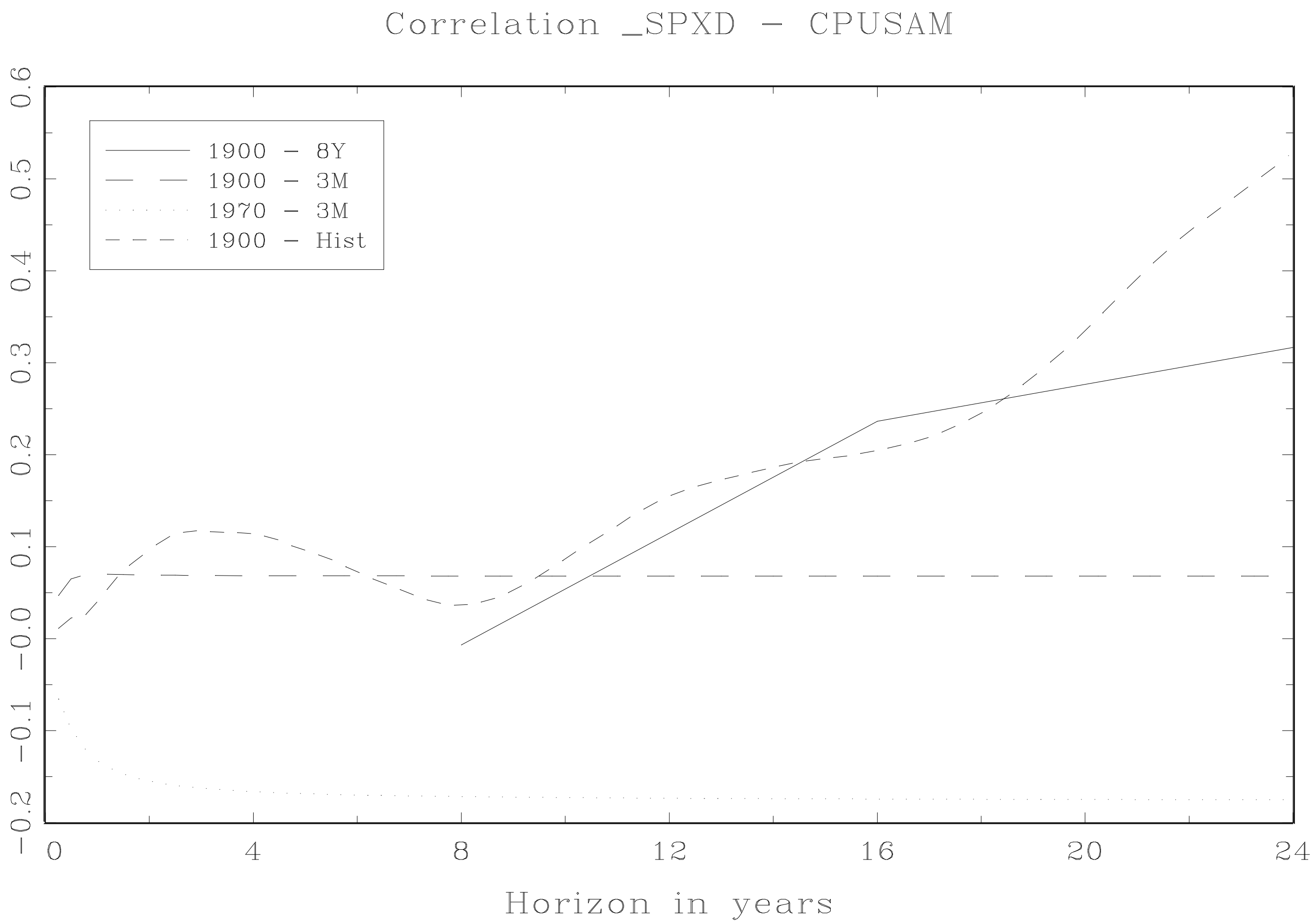
2. Economic and empirical features: At different horizons and frequencies, economies and financial markets behave differently and are dominated by different features (i.e. the challenges)
   A. Decomposing time series allows separate analysis of these features while spectral analysis can further unravel behavior
   B. Decomposed modeling approach allows for simultaneous capturing of these features with (different) time series models

Motivation - II

3. Samples and data frequencies: Use appropriate time series data in terms of samples and frequencies to analyze and model various features and combine all sources of time series information

- Example
  - US CPI – Stock Price correlations up to 24 year horizon
  - January 1900 – December 2008 sample
  - Compare historical correlations with correlations implied by VAR(1) models estimated on quarterly and eight annual data

Horizon, data samples and frequencies

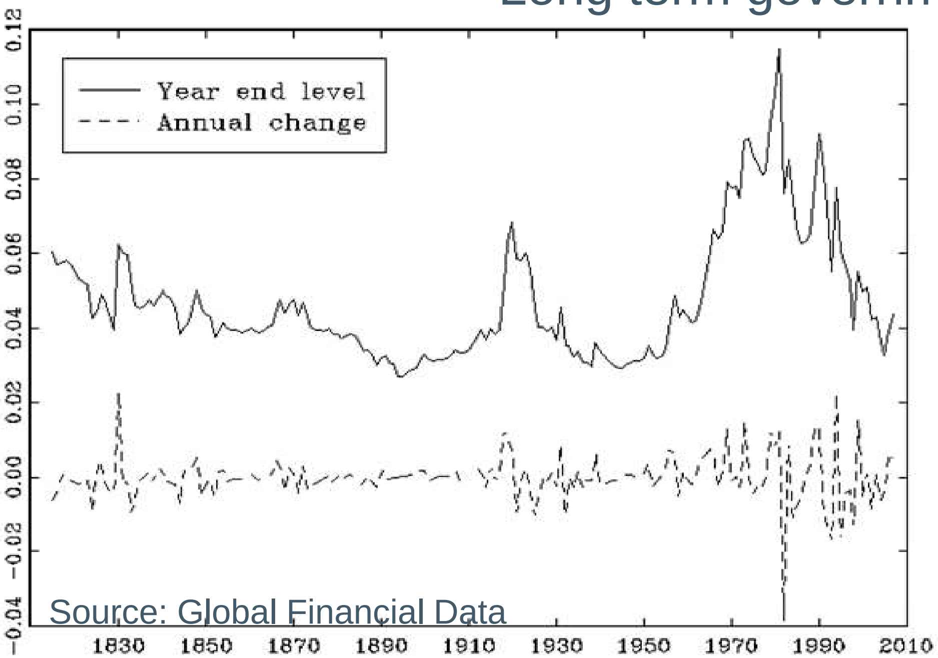


- Different correlations at different horizons (“term structure”)
- Risk of modeling on inappropriate data samples and frequencies

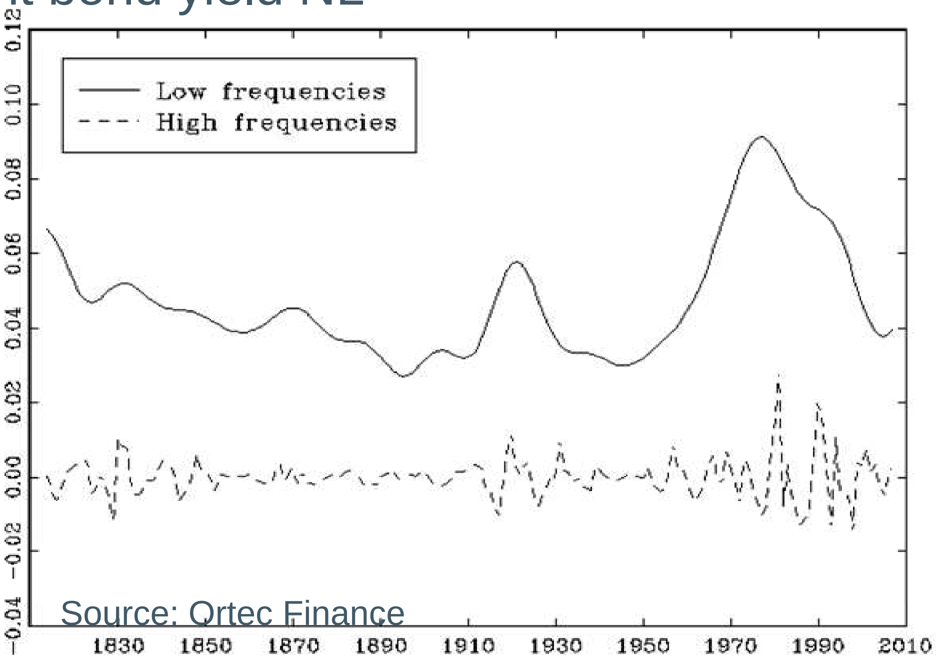
Motivation – III

4. Equal importance of all frequencies: Behavior in all frequency bands is equally important. Do not put focus on low *OR* high frequencies but allow for simultaneous focus on long *AND* short term behavior
   - Monte Carlo and backtesting experiments in Steehouwer (2010) and Lee and Steehouwer (2010) indicate superior performance possibilities

Long term government bond yield NL



Source: Global Financial Data

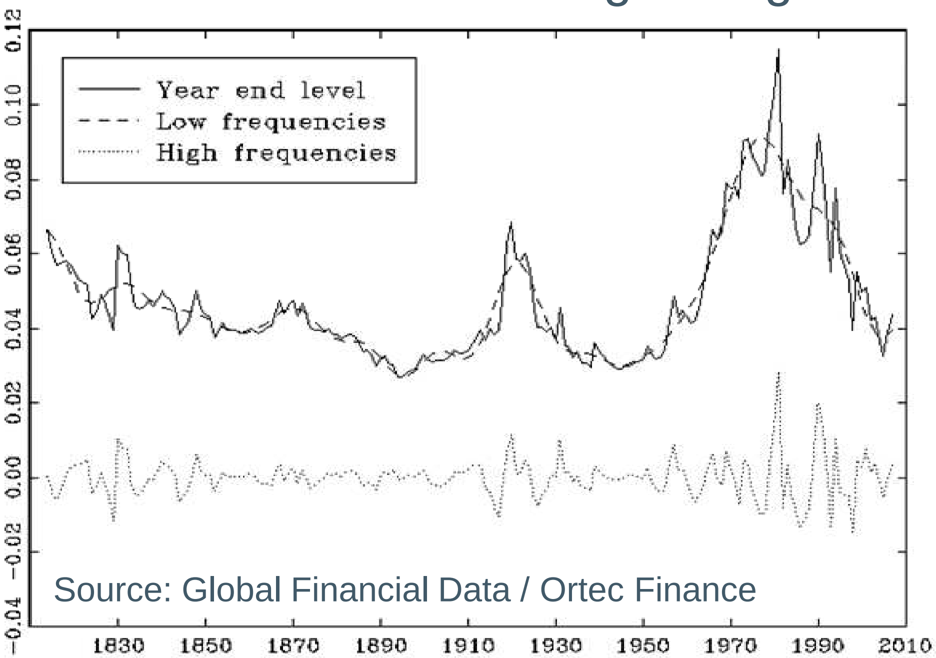


Source: Ortec Finance

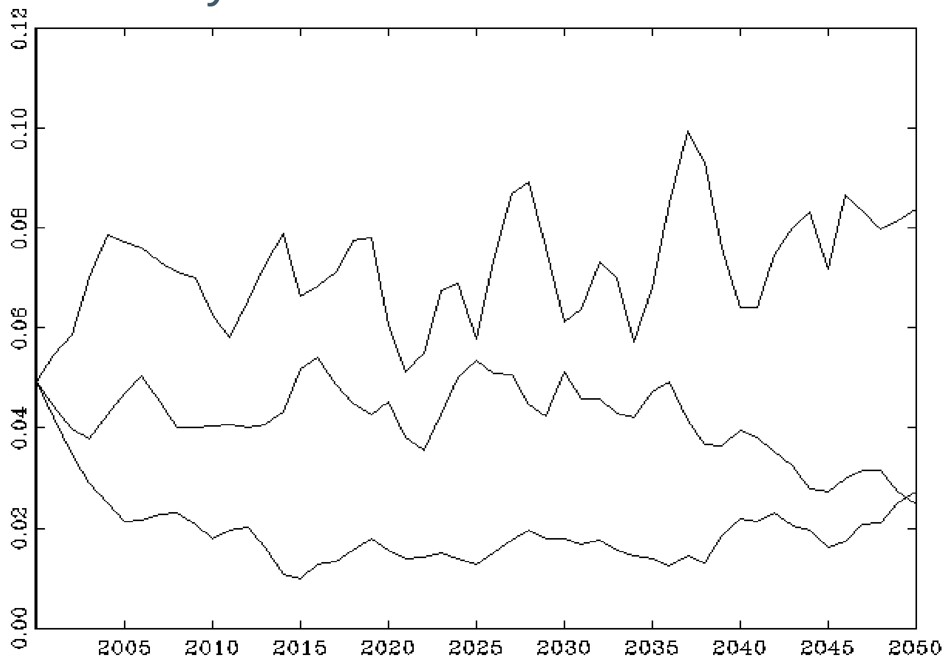
Motivation - IV

5. Complex dependencies between frequencies: Facilitate modeling of complex dependencies between features in different frequency ranges, ‘despite’ the orthogonal property
   - Example: ‘Level effect’ in short term interest rate volatility

Long term government bond yield NL



Source: Global Financial Data / Ortec Finance



Conclusions

- The number one challenge for (real world) ESG is to produce consistent multi-horizon, multi-frequency and multi-dimensional scenarios which capture all empirical features of economies and financial markets

- The described frequency domain methodology for time series modeling contributes by
  - Better insight and understanding of dynamic behavior of historical time series and models at different horizons and frequencies
  - Consistently combining data and model features at multiple horizons and frequencies

- Thereby providing one ESG to support all decision making in areas of strategy, implementation and monitoring and increase the quality of this decision making

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Questions or comments?

Expressions of individual views by members of The Actuarial Profession and its staff are encouraged.

The views expressed in this presentation are those of the presenter.

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