BANK NEDERLANDSE GEMEENTEN

ORTEC

Towards a new scenario generator with consistent short and long term economic scenarios

Part I: A frequency domain methodology for empirical macroeconomics

Netspar Pension Day

May 11, 2006

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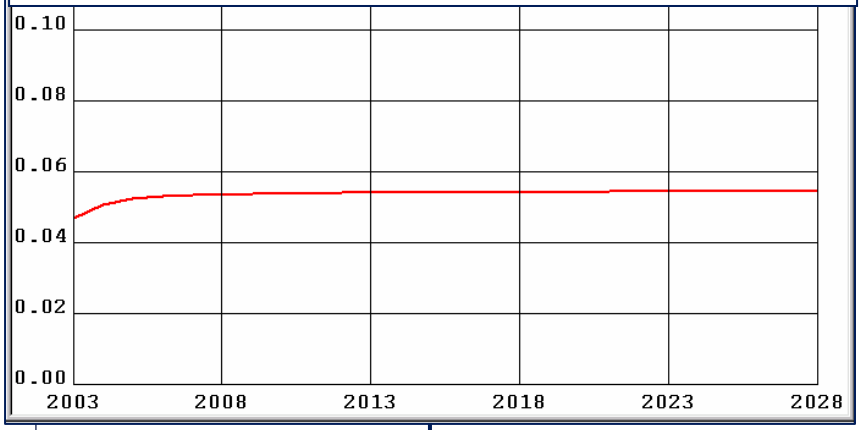
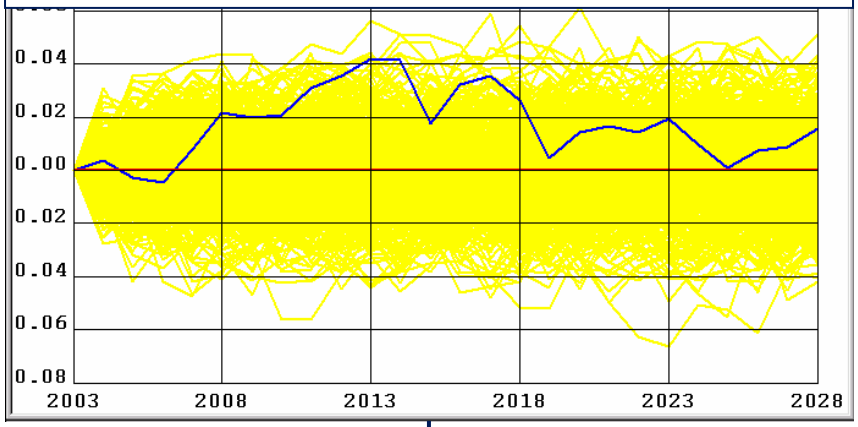
Introduction

Scenario components

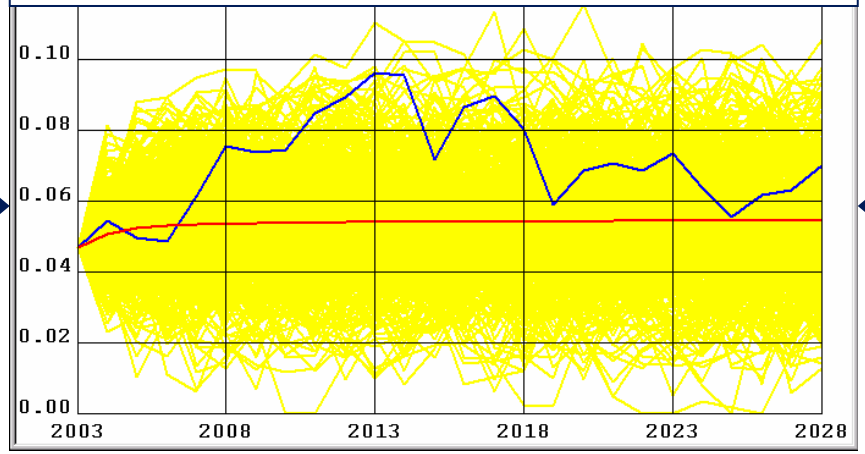
1. Expected / Predicted values



2. Stochastics / Deviations



Scenarios



- Scenarios are used to model the uncertainty in economic predictions
- Statistical properties (volatilities, correlations and dynamics) can all have a large impact on model results and thereby on policy decisions

Scenario analysis in (ORTEC) practice

- Scenario definition

“A scenario is a possible evolution of the future consistent with a clear set of assumptions”
(Bunn and Salo, 1993)

- 1. "Clear set of assumptions"
  - Scenarios in accordance with statistics of historical time-series
  - Plus forward looking adjustments of scenario statistics

- 2. "Consistent"
  - Vector AutoRegressive (VAR) time-series models

Long and short term scenarios

- Consistent and flexible modelling of long and short term economic scenarios more and more required
- More focus on short term risk for pension funds and insurance companies, for example as a consequence of nFTK
- Analysis of high frequency policy actions, for example monthly duration matching for an insurance company or rebalancing rules
- Consistent (pension) risk managament
  - 1. Asset Liability Management (ALM)
  - 2. ALM Implementation
  - 3. Portfolio construction
  - 4. Performance- and Risk Management

Two research questions

Question I

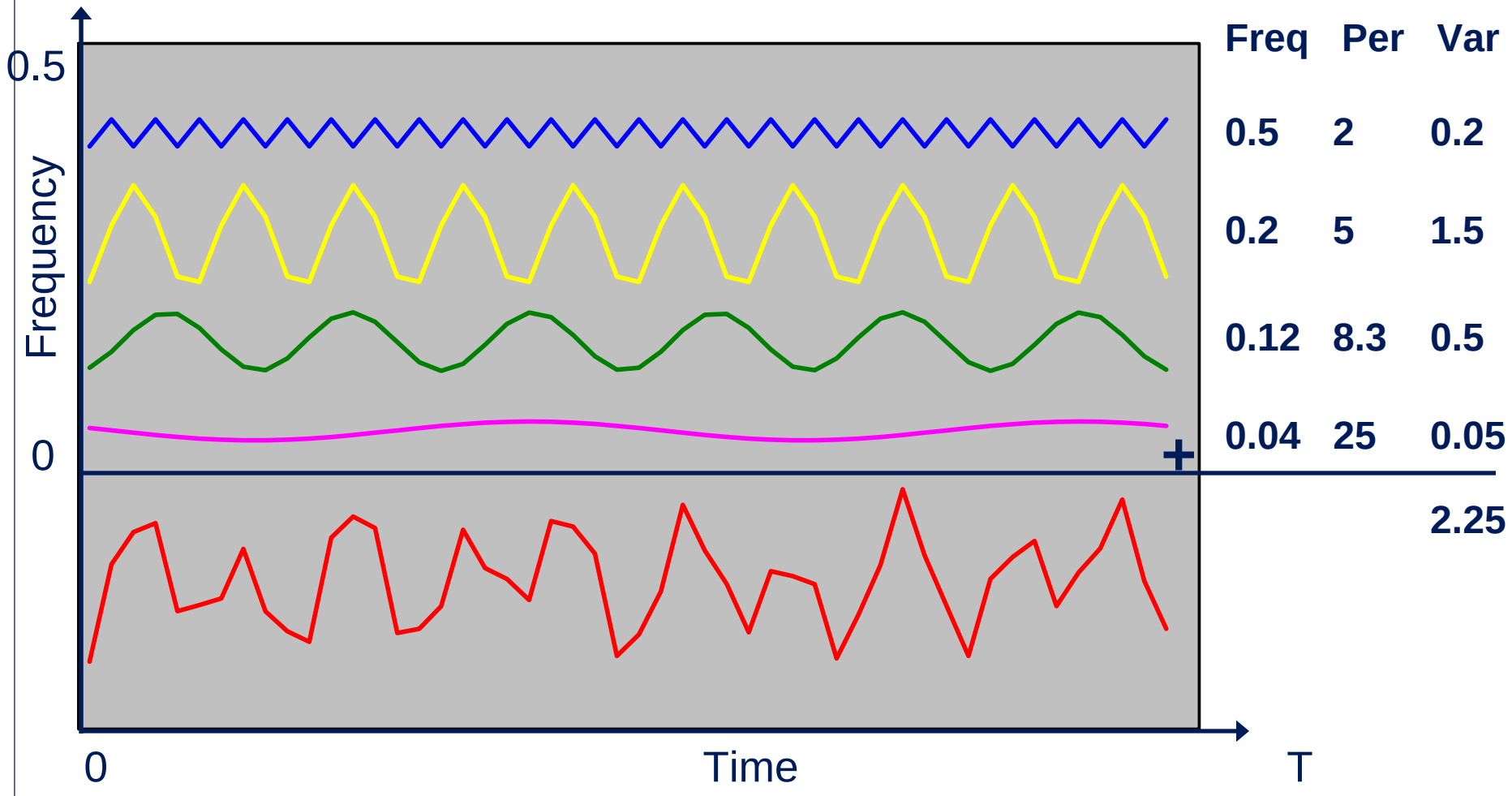
Which to scenario analysis and ALM relevant stochastic structures and relations have characterized the macroeconomic processes of developed countries in the past, with respect to both the real and financial sections of the economy and their interaction, the properties at different frequencies (ranging from the very long run to shorter term business cycles) and possible changes of these structures over time?

Question II

Do VAR models and, more important, the way they are applied in both academic and practical ALM, indeed lead to scenarios that are consistent with the empirical knowledge obtained from the first question and, if this is not the case, what modifications can be made to resolve the shortcomings of the current applications?

A frequency domain methodology for empirical macroeconomics

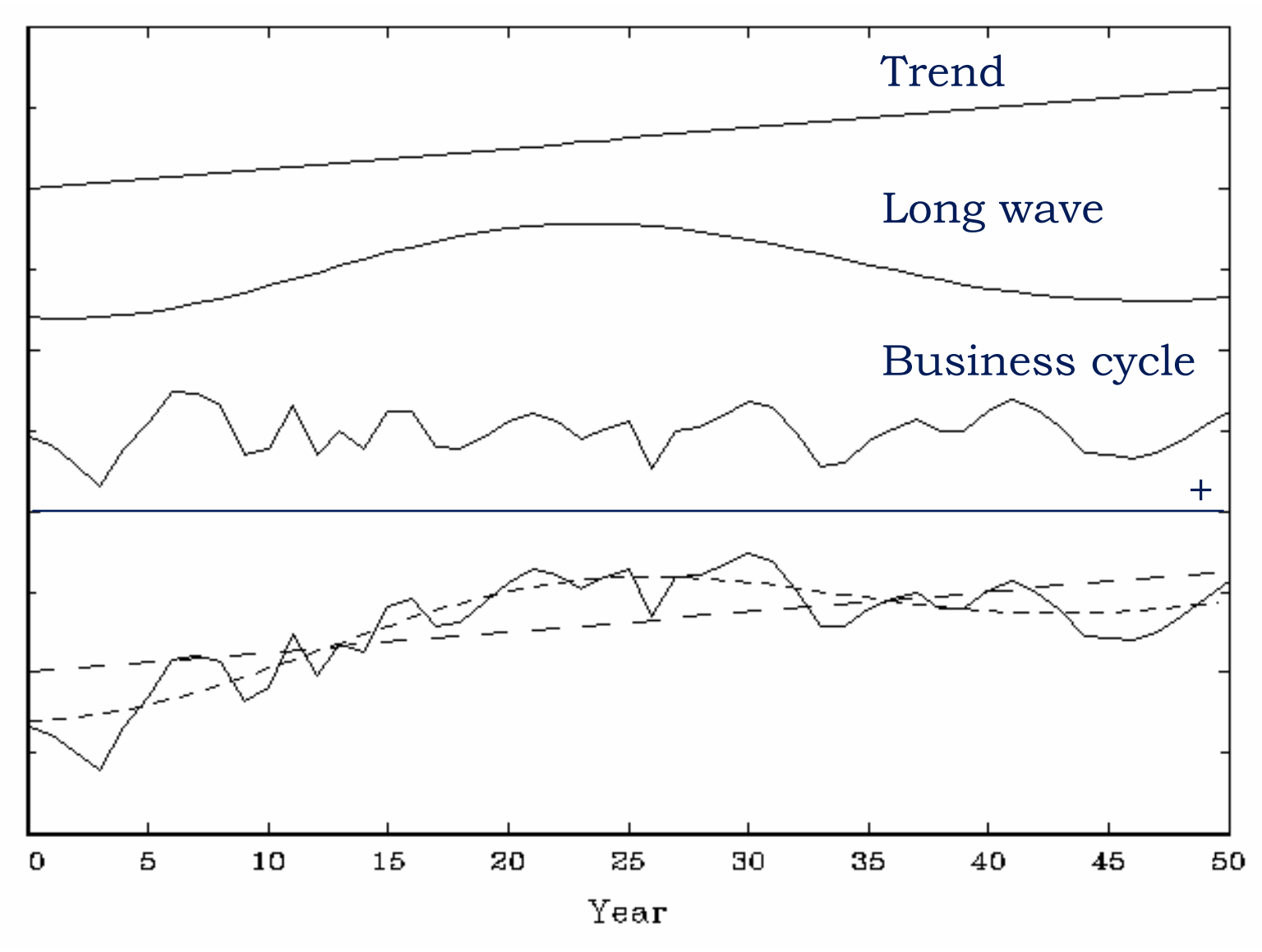
Time versus frequency domain



1. Decompostion of time-series

- A first application of the frequency domain is to decompose economic time-series into components which can be analyzed separately
  - Tinbergen: "Time-series = Trend + Cycle + Seasonal + Random"
  - Application of wrong filtering techniques can yield spurious results
- Filter requirements
  - Precise user definition of which frequencies to include and exclude
  - No shifts in time
  - No loss of data at the beginning and end of the sample
- Techniques
  - Many conventional filtering techniques fail one or more of these requirements
  - A special zero phase frequency filter meets all these requirements
- This zero phase frequency filter yields similar results as the popular Baxter-King and Christiano-Fitzgerald filters but
  - More precise (not an approximation)
  - No loss of data
  - No shifts in time

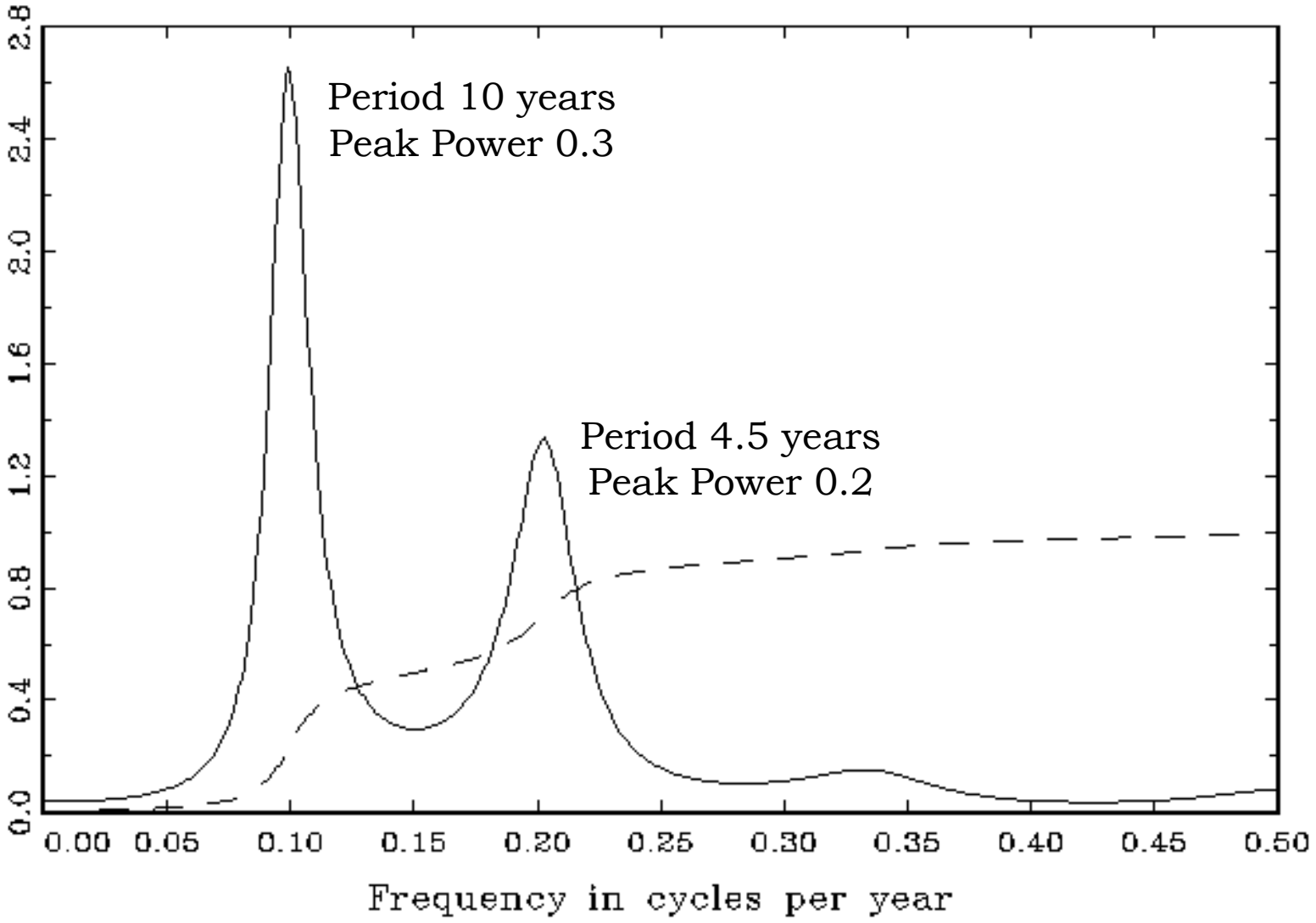
Example


Trend
Long wave
Business cycle
+
0
5
10
15
20
25
30
35
40
45
50
Year

2. Spectral analysis

- A second application of the frequency domain is to further zoom in on the stochastic behaviour of components by means of spectral analysis
  - Spectral analysis is a very powerful instrument for analyzing the dynamics of both univariate and multivariate stochastic processes
  - Nevertheless not in main stream econom(etr)ics due to in general non-experimental short samples
- Techniques
  - Traditional non-parametric spectral estimators suffer from disturbing leakage effect, especially in case of small samples
  - Use Maximum Entropy or autoregressive spectral analysis instead
- Maximum Entropy spectral analysis comes down to
  - Estimate autoregressive model and calculate spectrum of this model
  - Theoretical foundation: This results in spectral estimator with the *least* additional information that is not already contained in the sample
  - Monte Carlo experiments show that it is best to use the Yule-Walker technique for estimating the autoregressive model

Spectral density



Stylized facts and data

- Data requirements follow from first research question
- We can only speak of stylized facts if the regularities are found to be robust with respect to both historical time period and country
- Therefore longest possible samples of annual time-series for the Netherlands, United States and United Kingdom

Table 6.1 Start of the various annual macroeconomic time series, all ending in 1999.

	Netherlands	*United Kingdom*	*United States*
National Product Index	1870	1855	1870
Industrial Production Index	1921	1855	1860
Employment	1911	1855	1890
Consumer Price Index	1813	1600	1820
Real Industry Wage Index	1926	1829	1820
Short Term Interest Rates	1828	1820	1831
Long Term Interest Rates	1814	1700	1798
Default Spread	-	1929	1857
Real Equity TRR Index	1824	1800	1870

Steps in analysis

- Three steps for each variable and some important transformations
  - Real interest rate
  - Difference between long and short term interest rate
  - Dividends and capital growth
  - Equity risk premium

- 1. Data analysis
  - Conventional graphical and statistical analyis
- 2. Filtering analysis
  - Decomposition into trend, long waves and business cycles
- 3. Spectral analysis
  - Zooming in on the business cycle component
  - Separate estimates for prewar, interwar and postwar periods
  - Rolling window estimates to detect changes during postwar period

Summary of 90 stylized facts

Trends

Table 17.1 NP: National Product volume index, IP: Industrial Production volume index, EM: Employment rate, PI: Consumer Price index, WI: Real industry Wage Index, SR: Short term interest Rate, LR: Long term interest Rate, TS: Term Spread, DS: Default Spread, TR: Real equity Total return Index, RR: (ex post) Real long term interest Rate, CG: Real equity Capital Growth, DY: Equity Dividend Yield and RP: (ex post) equity Risk Premium.

	Historic					*Filtered trend component*				
	Type	*NL*	*UK*	*US*	*Avg*	*Type*	*NL*	*UK*	*US*	*Avg*
NP	Growth	2.7%	2.0%	3.3%	2.7%	Log Linear*	2.8%	1.9%	3.2%	2.6%
IP	Growth	3.6%	2.1%	4.0%	3.2%	Log Linear	4.0%	2.1%	4.0%	3.4%
EM	Level	94.9%	95.1%	93.1%	94.4%	Average	95.1%	95.3%	93.3%	94.6%
PI**	Growth	-0.4% / 3.2%	0.2% / 4.1%	0.2% / 3.1%	0.0% / 3.5%	Log Linear	-0.2% / 3.4%	0.4% / 4.3%	0.5% / 3.1%	0.2% / 3.6%
WI	Growth	1.2%	1.2%	1.0%	1.1%	Log Linear	1.6%	0.3%	1.1%	1.0%
SR	Level	3.6%	4.2%	5.5%***	4.4%	Average	3.4%	4.0%	5.4%	4.3%
LR	Level	4.8%	4.6%	5.0%	4.8%	Average	4.7%	4.6%	4.9%	4.7%
TS	Level	1.1%	0.5%	-0.7%***	0.3%	Average	1.0%	0.4%	-0.4%	0.3%
DS	Level	-	0.9%	1.1%	1.0%	Average	-	1.1%	1.1%	1.1%
TR****	Growth	8.0% / 6.5%	6.2% / 5.0%	8.4% / 6.8%	7.5% / 6.1%	Log Linear	5.9%	4.1%	6.1%	5.4%
RR	Level	3.3%	3.2%	3.0%	3.2%	-	-	-	-	-
CG****	Growth	2.6% / 1.2%	2.2% / 0.8%	3.3% / 1.7%	2.7% / 1.2%	-	-	-	-	-
DY	Level	5.7%	4.8%	4.5%	5.0%	-	-	-	-	-
RP	Level	5.2%	3.3%	6.2%	4.9%	-	-	-	-	-

* This means that the natural logarithm of the series has a linear trend and therefore that the original variable has an exponential trend with the indicated average growth rate.

** Contains a structural break around 1900. Therefore separate results for the pre-1900 and post-1900 periods are reported.

*** Unusually high or low value probably because of the large credit risk premiums present in the 19th century US short term interest rates. See section 12.1.

**** First is the arithmetic average of the actual returns, not approximated as the first order differences of the natural logarithm of the series. Second is the geometrical average.

Long waves

- Around the long term trends or averages, the development of both real and financial macroeconomic variables are without exception for a substantial part characterized by worldwide *long wave* or *Kondratieff* type fluctuations with an average period length of approximately 50 years. The approximate dating of the subsequent peaks and troughs is given below.

		1		*2*		*3*		*4*		*5*	*Peak-Peak Trough-Trough Lead*
Average		1826	*42*	1868	*52*	1920	*52*	1972			*49*
	1790	*57*	1847	*47*	1893	*54*	1947	*47*	1994		*51*

Business cycles

- Business cycle fluctuations describe more than 90% of the volatility (standard deviation) of the standard deviations of the original, not filtered, growth or return rates.

- *Juglar* type business cycle fluctuations
  - have been (statitically significantly) present in all macroeconomic variables for as long as data has been collected for these variables
  - have an average period length of approximately 10 years
  - typically describe 30% of the total business cycle variance and
  - have high phase corrected correlations (coherence)

- *Kitchin* type business cycle fluctuations
  - have an average period length of approximately 4.5 years
  - typically describe 20% of the total business cycle variance and
  - have high phase corrected correlations (coherence) though lower than the Juglar type fluctuations

Long term changes

- Except for interest rate related variables, business cycle fluctuations have had the greatest *volatility* during the turbulent interwar period. Furthermore, the volatility during the postwar period is lower than during the prewar period.

- For the interest rate related variables, the volatility during the prewar and interwar periods is comparable while it is (much) greater during the postwar period (level effect).

- *Business cycle dynamics* have in general been remarkably *stable* when compared for the prewar, interwar and postwar period. This holds both for the *relative volatilities* between the various variables and for the properties of the (normalized) spectral densities.

Postwar changes

- The typical length of the Juglar business cycle fluctuations in the NL has *lengthened* by approximately 2 years
- The contribution of the Juglar fluctuations to the total variance of the business cycle fluctuations has *increased* by 5% points.
- Juglar type business cycles have become 9% points *more regular*.
- The *international coherence* between the Juglar business cycle fluctuations in the NL, UK and US has *increased* by 27% points.
- The *domestic coherence* between the Juglar business cycle fluctuations in various variables has *increased* by 9% points.

Conclusions Part I

- A frequency domain methodology consisting of
  - the zero phase frequency filter
  - and Maximum Entropy spectral analysis

  constitutes a very efficient, clear and consistent approach for analyzing historical time-series of economic variables

- Using this methodology, almost 90 stylized facts have been obtained about the empirical behavior of important macroeconomic variables in the Netherlands, the United States and the United Kingdom

- The results can serve as a complete and consistent reference for all those interested in the empirical behavior of macroeconomic variables

- The results also serve as starting point for modelling economic scenarios for ALM and Risk Management purposes (Part II)