Leading indicators for the house price

A traditional and a spectral analysis approach

The purpose of the research is the construction of house price forecasts for the short to the medium term on basis of the leading character of housing market influencing variables.

Initial dataset

House market related

- # transactions
- (sales)time on the market
- # supplied construction permits
- rental price
- # supplied mortgages
- supplied mortgages (money terms)
- order portfolio of construction firms
- Construction costs

Economic/monetary

- long term interest rate /mortgage rate
- short term interest rate
- cpi-index
- money supply (M3)
- income (gdp)
- AEX-index (stock prices)
- consumer/business confidence
- unemployment

House price determination

elastic demand

- demography
- funding possibilities

inelastic supply

- existing house stock
- increase house stock, both quantitatively and qualitatively

institutional context

- public housing policy
- space planning (vinex)
- tax deductibility of mortgage rate payments

Procedure

Time series decomposition

⇨ trend, cyclical, seasonally and noise components

↓

Identify (business) cyclical component for each variable

↓

Compare each variable to cyclical house price

⇨ selection on basis of *similarity* (correlation) and *time lead*

↓

Replicate cyclical house price with shifted variables

⇨ implicit prediction by the minimum time lead of the selected variables

↓

Time series composition of trend and cyclical component

⇨ **house price prediction**

Traditional versus Spectral analysis

Business cycle approach

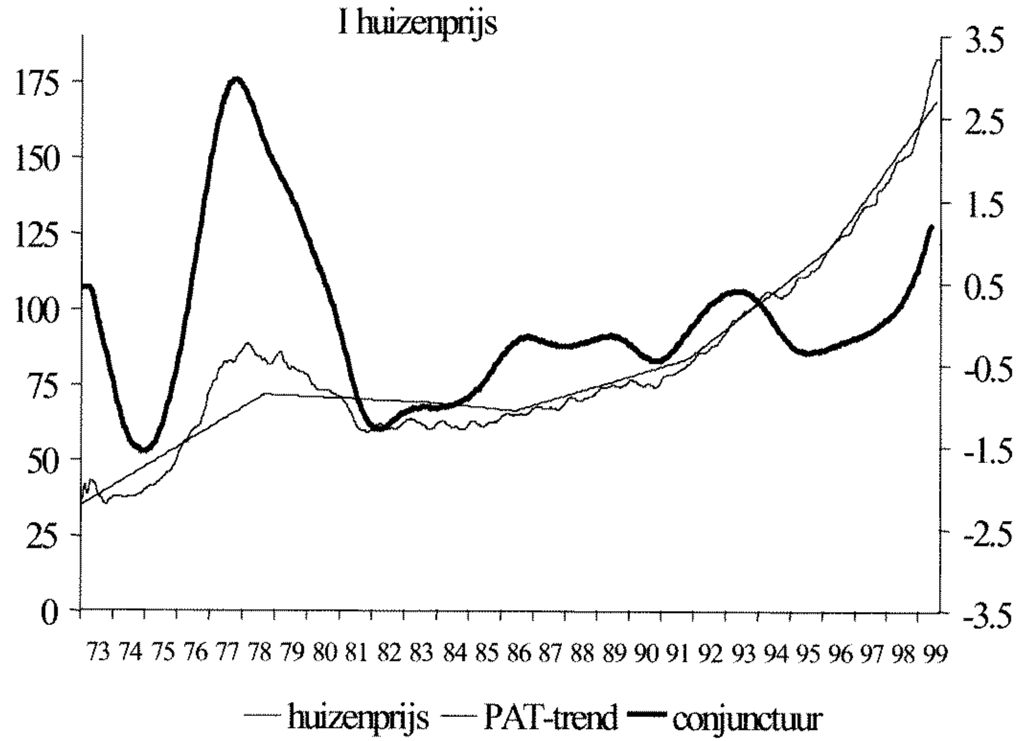
- barometrical indication of the state of the economy (house market).
- in the tradition of
  Van Duijn (1978)
  Bikker & Fase (1985)
  applied to the housing market
- deterministic trend algorithm which results in an interpretable cyclical component

Spectral analysis approach

- decomposition of a time series in waves
- define cyclical behavior as the part of the time series that can be described by waves with wavelengths smaller than 7 years
- Requires stationary series. So removing trend by differencing. Results in a non-interpretable cyclical component.

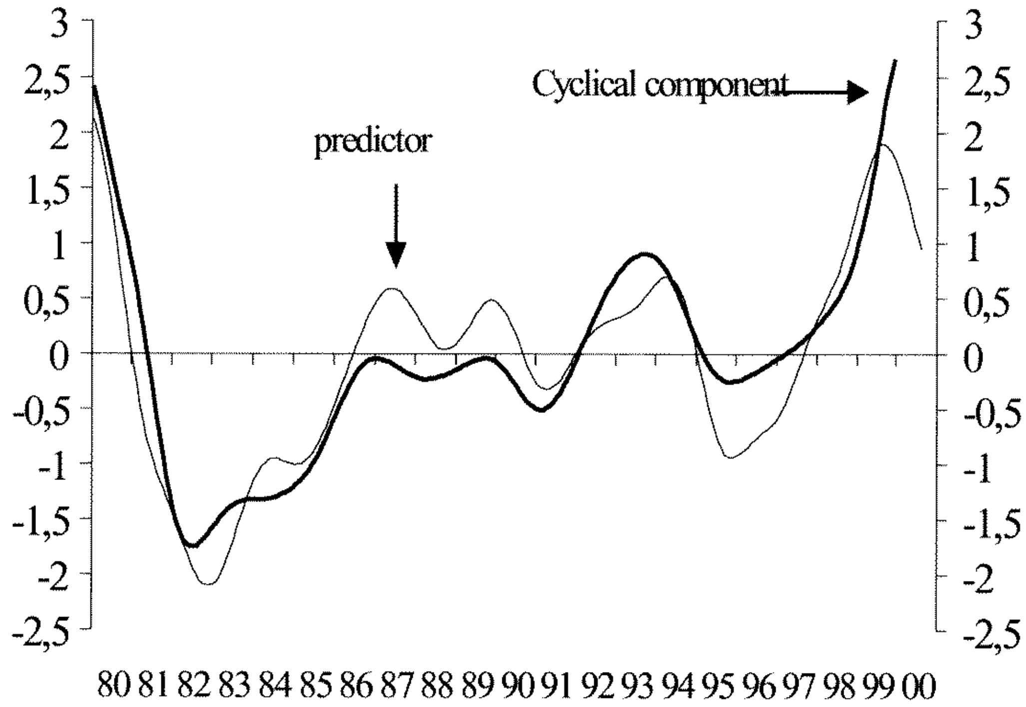
Results of the traditional approach 1

- cyclical figure after standardization and smoothing
- phase Average Trend (PAT) used
- last line segment of the trend not fully determined
- note the house price 'bubble' in the late seventies



Results of the traditional approach 2

- Indicators are
  *Long term interest rate
  *short term interest rate
  *credit production Rabobank
- lead is 6 months
- predictor is constructed by OLS on shifted variables
- fit: $R2=0.88$, corr=0.89



Spectral analysis (1)

A time series is quite often represented in an ARMA(p,q)-format, like:

$$y_t = a_0 + \sum_{i=1}^{p} a_i y_{t-i} + \sum_{i=0}^{q} b_i e_{t-i}$$

Alternatively, a time series can be projected on a goniometric (orthogonal) space, which results in

$$y_t = f(t) = \sum_{m=0}^{L(n)} \left(a_m \cos\left(\frac{2\pi m}{n} t\right) + b_m \sin\left(\frac{2\pi m}{n} t\right)\right),$$

$$t = 0,1,\ldots,(n-1), \quad m = 0,1,\ldots.,L(n)$$

Spectral analysis 2

Fourier transformation theorem:

without going into technical detail:

$$f(\omega)=\sum_{k=0}^{\infty}\left[a_k\cos(k\omega)+b_k\sin(k\omega)\right]\overset{\text{Fourier theorem}}{=}\frac{1}{2\pi}\sum_{k=-\infty}^{\infty}e^{-i\omega k}\rho(k)$$

$\omega=\frac{2\pi t}{n}$ for $n\rightarrow\infty$,

$\rho(k)$ is the ke autocorrelation

Multivariate spectral analysis

$$f_y(\omega) = \frac{1}{2\pi}\sum_{j=-\infty}^{\infty}\Gamma(j)e^{-i\omega j} = \{f_{y_u y_v}(\omega) : u, v = 1,\ldots,n\}$$

$$f_{y_u y_v}(\omega) = \frac{1}{2\pi}\sum_{j=-\infty}^{\infty}\gamma_{y_u y_v}(j)\{\cos(\omega j) - i\sin(\omega j)\} = c_{y_u y_v}(\omega) - iq_{y_u y_v}(\omega)$$

Note that

$$\gamma_{xy}(j) = \gamma_{yx}(-j)$$

but not necessarily equal to $\gamma_{xy}(-j)$

Multivariate spectral measures

- Coherency spectrum (interpretable as a correlation coefficient in the frequency domain:

$$\mathrm{K}_{\mathrm{xy}}^{2}(\omega)=\frac{\left|f_{xy}(\omega)\right|^{2}}{f_{xx}(\omega)f_{yy}(\omega)}$$

- Phase spectrum and shift spectrum. The latter measures the time difference between two time series.

$$\varphi_{xy}(\omega)=\tan^{-1}\left(\frac{-q_{xy}(\omega)}{c_{xy}(\omega)}\right) \quad \text{phase spectrum,}$$

$$s(\omega):=-\left\{\frac{\varphi(\omega)}{\omega}\right\} \qquad \text{shift spectrum.}$$

Example

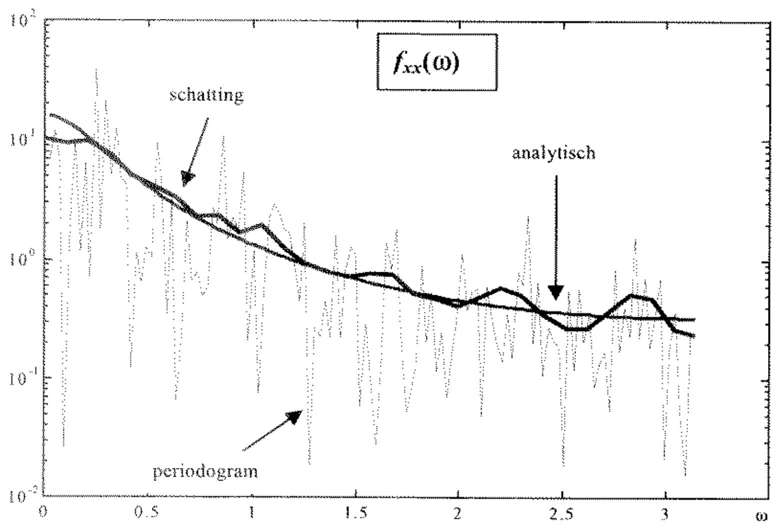
$$y_t = b_1 y_{t-1} + e_{y,t}$$

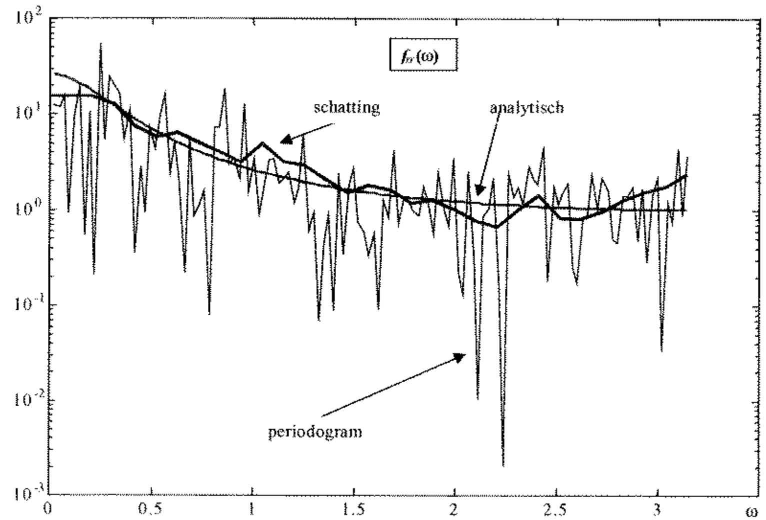
$$x_t = a_1 y_{t-4} + a_2 y_{t-5} + e_{x,t},$$

with $|b_1| < 1$ and $\{(e_{y,t}, e_{x,t})'\}$ a vector series uncorrelated random variables, with :

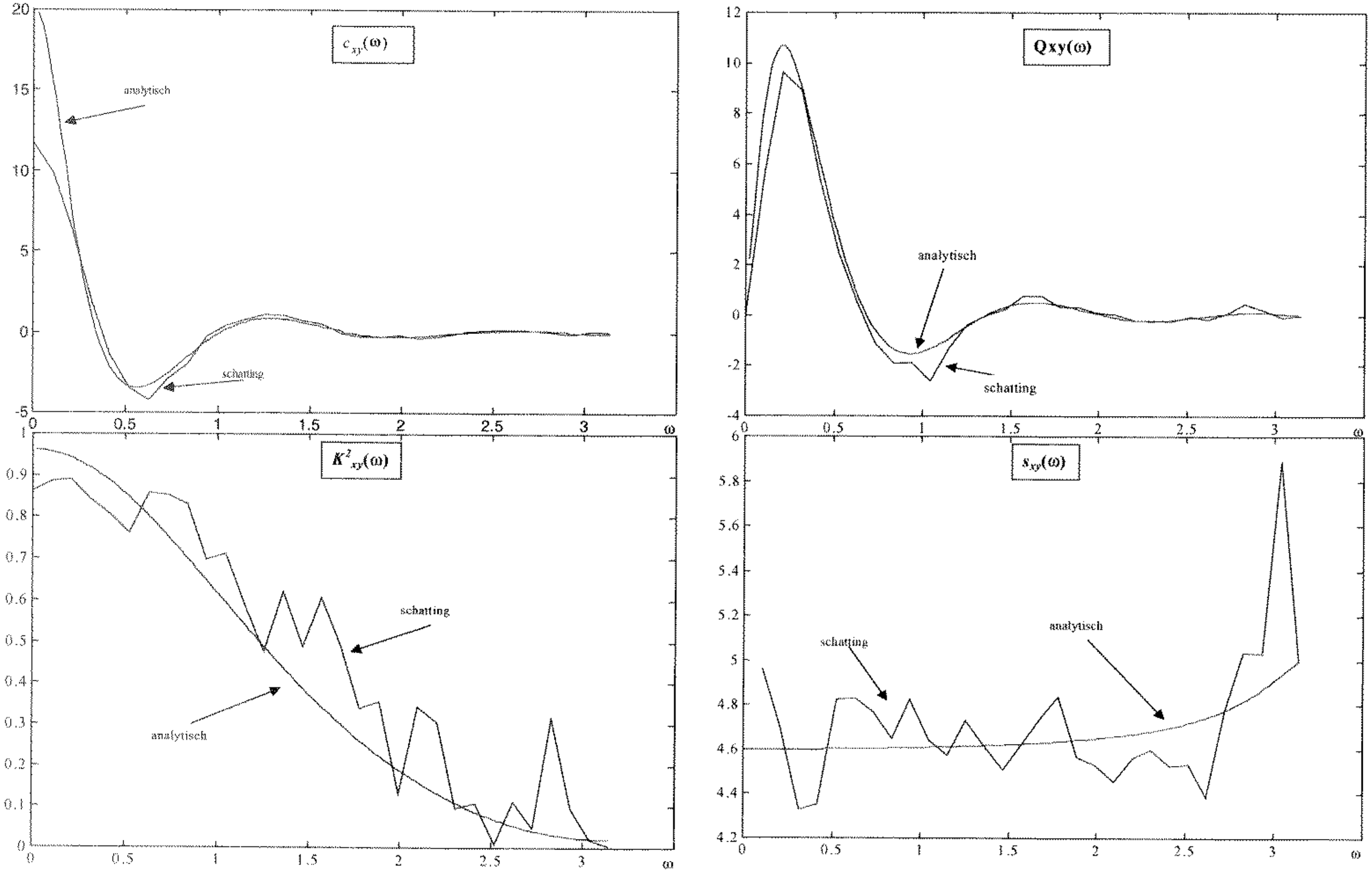
$$E(e_{y,t}^2) = \sigma_{yy} = 1, \quad E(e_x^2) = \sigma_{xx} = 1, \quad E(e_{y,t}e_{x,t+h}) = 0 \quad \forall t, h.$$

This model generates both by simulation and analytically:





Example (continued)



Procedure of the spectral approach

the procedure is as follows:

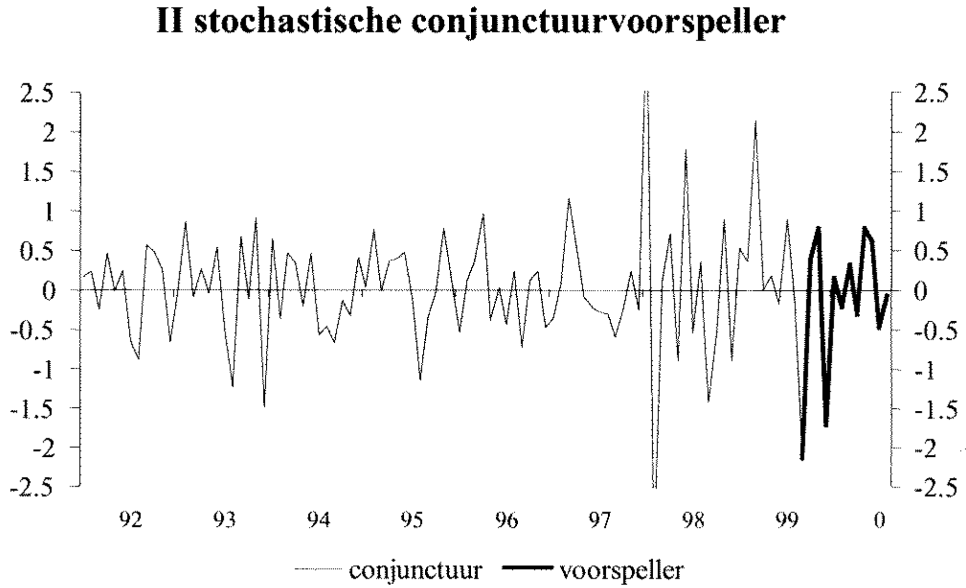
- define cyclical component as waves with lengths between 1 and 7 years
- determine the frequency interval with waves that constitute the cyclical component
- calculate the coherency spectrum and the shift spectrum
- calculate the average coherency and shift over the interval
- select the variables that perform best as leading indicators
- predict the house price with the following model:

$$HP_{t+s} = g_0 + \sum_{u=-(s_1-s)}^{T} g_1(u) LI_{1,t-u} + \sum_{u=-(s_2-s)}^{T} g_2(u) LI_{2,t-u} + \ldots + \sum_{u=-(s_q-s)}^{T} g_q(u) LI_{q,t-u} + N_{t+s}$$

$$s = \min\{s_1, \ldots, s_q\}$$

Spectral results

- Selected variables are
  - *short term interest rate
  - *mortgage interest rate
  - *time on the market
  - *cpi-index
- Prediction is calculated with an inverse Fourier transformation:



$$f_{xy}(\omega) = T(\omega) f_{yy}(\omega) \quad \Leftrightarrow \quad T(\omega) = f_{xy}(\omega) f_{yy}^{-1}(\omega)$$

$$g(u) = \int_{-\pi}^{\pi} f_g(\omega) e^{i\omega u}\, d\omega = \frac{1}{2\pi} \int_{-\pi}^{\pi} T(\omega) e^{i\omega u}\, d\omega \qquad u = 0, \pm 1, \pm 2, \ldots$$

Comparing the predictive power

Backtesting: *6 months predictions
*period 30 months
*out of sample