Is the economy constantly in labour?

- a far-reaching comparison
between financial time series and fetal heart rhythm
during labour

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Contents

- A different perspective - what happens after the crash?

- Fetal heartbeat & economy or Econophysics vs Cardiophysics?!

- Breaking with the universality picture in favour of: i) local view ii) complex interactions with the environment

- Towards a fetal surveillance system

- Can lessons be learned for economy decision support?
A usual focus of interest - predicting the crash...
A different perspective - what happens after the crash?

- volatitily increase
- increase in (anti-)correlations \((H \leq -0.5)\)
- increase of multifractal spectrum width

- multiscale crashes (and ‘rallies’) constitute the stock index
- the question we ask is whether the economy remains ‘healthy’
The Hölder Exponent

- The ability of the Wavelet Transform to filter polynomials of degree $P_n$ is particularly useful for us since it allows the assessment of local scaling behaviour.

- This scaling behaviour is represented by the so-called Hölder exponent $h(x_0)$ of the function $f(x)$:

$$|f(x) - P_n(x - x_0)| \leq C|x - x_0|^{h(x_0)}$$

- We can be tempted to extract $h(x_0)$ from the scaling of the wavelet transform $Wf(x_0, s)$. 
For our purpose, the local information is essential

- Local version of Hurst exponent H - Hölder exponent h

Local contributions to the ‘traditional’ multifractal spectra

- Healthy heartbeat interbeat intervals and white noise
- Multifractal process vs monofractal noise
• The local (effective) $h$ determines local contributions to the multifractal spectrum

• With all its monochromatic, i.e. mono-fractal, components separable!
• Link to the external temporal information reveals structure!

• Autocorrelation function confirms the presence of invariant, intra-day periodic structure.
Why Wavelets?

- Reveal the hierarchy of (singular) features including the scaling behaviour.
- Provide means of local analysis.
- In particular in the presence of non-stationarities like global or local trends or biases.
After-crash oriented is the perspective of perinatology - is the fetus still OK?
But how does this fetal ‘crash’ compare to the stock index crash?

- volatitily increase
- increase in (anti-)correlations ($H \leq -0.5$)
- increase of multifractal spectrum width

Fractionally integrated fetal heartbeat record

- full multifractal spectrum
- centred at $H = 0.5$
Fractional Differentiation

![Fractional Differentiation Graphs]

Fractional Integration
Let us look closer at the heart

- Fetal heartbeat is the *only* indicator of the well-being of the fetus during labour
- Main actors: parasympathetic ↓ versus sympathetic ↑ system
- Order of 10-100 degrees of freedom
- Degree of supply of oxygen driven (good or bad news...)

Conduction system of the heart Image copyright 2000 by Nucleus Communications, Inc. http://www.nucleusinc.com
Currently used in obstetrics decision making:

- Baseline level
- Density and volume of decelerations (‘crash’) and accelerations (‘rally’)
- Variability (volatility) level

(To be) suggested for use in obstetrics decision making:

- Variability correlation and ‘multifractality’ level after the ‘crash’
- ‘Speed’ of recovery from the ‘crash’
Let us look closer at the stock exchange

- The stock index is the indicator of the well-being of the economy
- Main actors: buyers (optimists) ↑ versus sellers (pessimists) ↓
- Order of 1,000-10,000 degrees of freedom
- Good or bad news driven...

Dow down — Trader Aram Adler reacts near the close of trading in the Dow Jones futures pit ... AP
Currently used in economy evaluation (and decision making):

- Slope level (corresponds with heartbeat baseline integral)
- Size of crashes (decelerations) and rallies (accelerations)
- Volatility level (variability)

Not yet suggested for use in economics decision making:

- Variability, correlation and ‘multifractality’ level after the ‘crash’
- ‘Speed’ of recovery from the ‘crash’
Fetal heartbeat surveillance during labour

• Problem statement:

  – fetal heartbeat is highly non-stationary

  – fetal heartbeat needs to be monitored in real time

  – standard (multi-)fractal characteristics fail dramatically

• Proposed solution:

  – running, real-time decomposition scheme

  – separating meaningful components of fetal heartbeat

  – constructing meaningful real-time indicators - e.g. cumulative $h$

  – consulting additional information in a Bayesian belief network

• In collaboration with

  Wim J. van Wijngaarden

  Academic Medical Centre (AMC), Amsterdam
• Reasoning with non-stationarity - exploring multiple order interactions between extracted features and

  - age of mother
  - number of children alive
  - number of neonatal deaths
  - number of stillbirths
  - gestational age at delivery
  - drugs to stimulate contractions
  - biochemical variables
  - Apgars scores
  - ...

• For monitoring

• For prediction

• In collaboration with

  Robert Castelo

  *Utrecht University*
• A Bayesian network is a graphical model

• It encodes probabilistic relationships among variables of interest

• It has several advantages for data analysis:
  
  - it readily handles situations where some data is missing
  - it can be used to learn (causal) relationships
  - and hence to gain understanding about a problem domain
  - and to predict the consequences of intervention
  - it is ideal for representing prior knowledge and data

• Simplified version of the best dependence network
Conclusions

- We have used the failure of multifractal paradigm to our advantage

- We have employed non-stationarity of the local $h$ in fetal surveillance

- Using Bayesian belief networks, we have captured the basics of the obstetrics reasoning process

- The exact nature of correlations between the temporal features and fetal outcome has still to be determined

- A possible improved functional relation with more predictive power and physiological foundation (to replace cumulative $h$) will be sought for